BLM LIBRARY
88065993

Summary

~~WSO LIBRARY~~

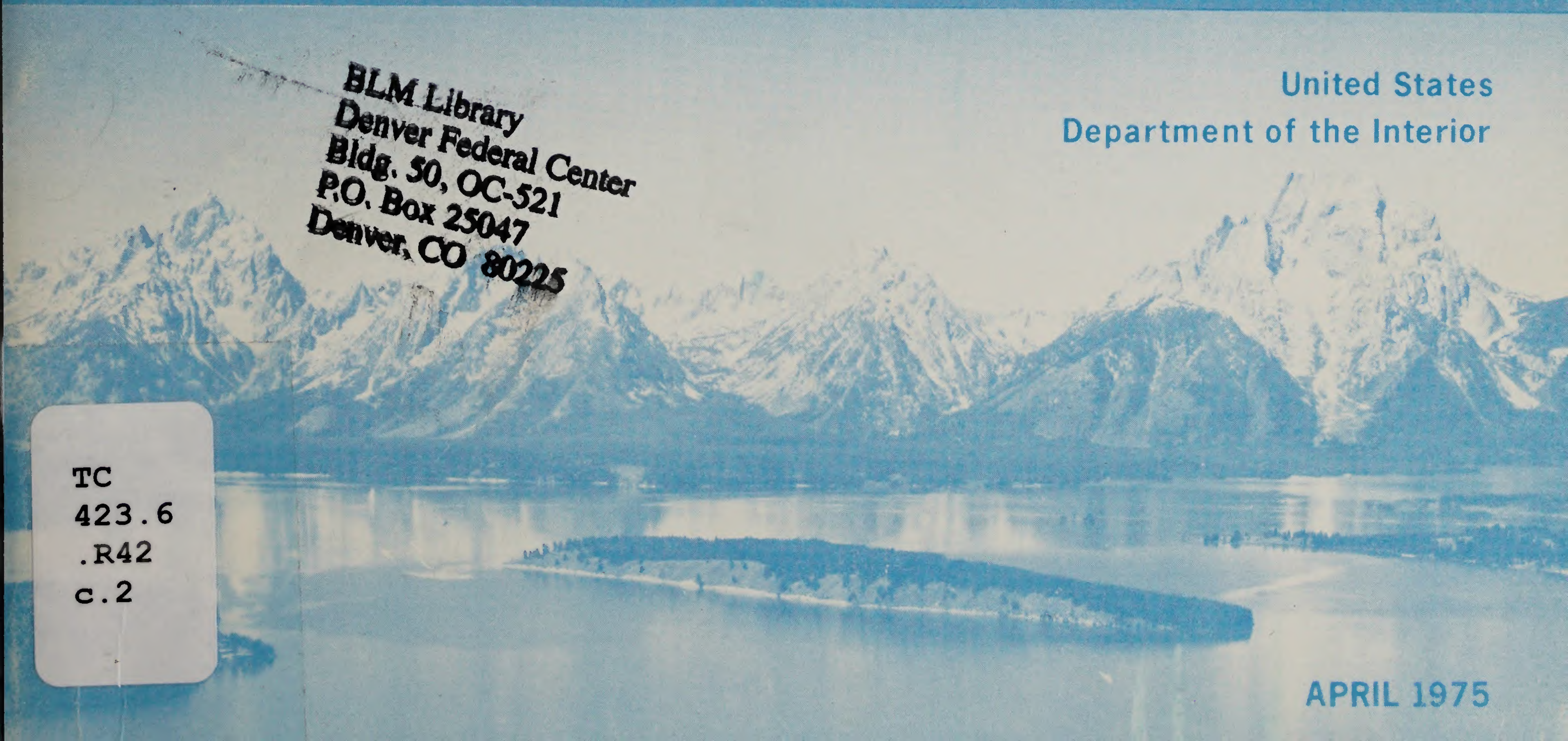
Routing 10/23/75 Initial & Date
SD
ASD
1 ESPC mae
OPA
2 Res.
Tech S.
Mgmt S.
3 GF 1792.6
Lead Resp. /

EXECUTIVE SUMMARY OF

Critical Water Problems Facing the Eleven Western States

~~WSO LIBRARY~~

WESTWIDE STUDY



BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

United States
Department of the Interior

TC
423.6
.R42
c.2

APRIL 1975

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

#1969035

ID: 88065993

TC
423.6
.R42
c.2

~~WSO LIBRARY~~

EXECUTIVE SUMMARY OF

Critical Water Problems Facing the Eleven Western States

UNITED STATES DEPARTMENT OF THE INTERIOR
Rogers C. B. Morton, Secretary

BUREAU OF RECLAMATION
Gilbert G. Stamm, Commissioner

WESTWIDE STUDY
April 1975

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

FOREWORD

To:
The President
Water Resources Council
The Congress

This is an Executive Summary of my report on the critical water problems facing the 11 Western States. The report itself presents the results of the Western U.S. Water Plan Study initiated in 1969. Authorization for that study was provided by the Congress in the Colorado River Basin Project Act (Public Law 90-537) in September 1968. The act directed the Secretary of the Interior to conduct reconnaissance investigations for the purpose of developing a general plan to meet the future water needs of the 11 Western States lying wholly or in part west of the Continental Divide.

Western water resources programs generally have not fully addressed the needs and desires of the people of the Nation's highest growth-related region; instream flow requirements and Indian water needs are still being identified and quantified. Water requirements in the Western States have increased at phenomenal rates in recent years and pressures have mounted to develop the vast natural resources of the West while at the same time providing greater safeguards for the national environment and more water for fish and wildlife, recreation, and a general quality of life.

Since the passage of the act, new national priorities have emerged. Satisfaction of national energy and food and fiber needs, emerging land-use policies, and the need for adequate programs to enhance the environment place new demands on planning for development of the resources of the Western States. Development of the West's energy mineral reserves, timber, and other food and fiber resources for national use may conflict with other national priorities, but the development of these resources is increasingly urgent.

This Executive Summary was prepared for those who have a need for the essence of the report. It briefly describes problems which relate in scope to the 11 Western State area, regions within that area, and to the individual States. It is an important and valuable document for those people interested in the proper use and care of our valuable natural resources.

ROGERS C. B. MORTON
Secretary, United States
Department of the Interior

ACKNOWLEDGMENT

The Westwide Study represents the joint efforts of representatives of the 11 Western States, commissions representing regional and national interests, nongovernmental organizations, and the Federal Government. All those involved helped to make possible the valuable contribution of the Westwide Study.

Participants were organized into three groups whose functions are discussed in the introduction of the report. The three groups are the Advisory Committee, the Management Group, and the Implementation Group.

Participating in the Advisory Committee were representatives from:

Arizona
California
Colorado
Idaho
Montana
Nevada
New Mexico
Oregon
Utah
Washington
Wyoming

Pacific Northwest River Basins Commission
Missouri River Basin Commission
Colorado River Commission of Nevada
Colorado River Board of California
National Water Resources Association
Western States Water Council
League of Women Voters
Sierra Club
National Association of Counties
Four Corners Regional Commission
International Boundary and Water Commission (U.S. Section)
Izaak Walton League of America
American Farm Bureau Federation
AFL-CIO
Natural Resources Council of America
National Tribal Chairman's Association

Arkansas-White-Red Basin Inter-Agency Committee
Upper Colorado River Commission
Pacific Southwest Interagency Committee

Water Resources Congress
U.S. Chamber of Commerce
National Wildlife Federation
National Congress of American Indians
National Association of Conservation Districts
Western Systems Coordinating Council
American Water Works Association
Wildlife Management Institute
Rocky Mountain Center on Environment
National Grange
Trout Unlimited

Participating in the Management Group were representatives from:

- Water Resources Council
- Department of Agriculture
  - Economic Research Service
  - Forest Service
  - Soil Conservation Service
- Department of the Army
  - Corps of Engineers
- Department of Commerce
- Environmental Protection Agency
- Federal Power Commission
- Department of Health, Education and Welfare
- Department of Housing and Urban Development
- Pacific Northwest River Basin Commission
- Department of the Interior
  - Bureau of Indian Affairs
  - Bureau of Mines
  - Bureau of Sport Fisheries and Wildlife
  - Bureau of Outdoor Recreation
  - Geological Survey
  - Office of Saline Water
  - Bureau of Land Management
  - Bureau of Reclamation
- National Park Service
- Bonneville Power Administration
- Department of Transportation

Participating in the Implementation Group were field counterparts of the participating Federal agencies, representatives of the 11 Western States, the Pacific Northwest River Basins Commission, and consultants.

Primary responsibility for decisions rested with the Department of the Interior in consultation with the Water Resources Council and other Federal agencies. The Bureau of Reclamation of the Department of the Interior was the lead agency for the study and preparation of this summary for printing was done through the facilities of the Bureau of Reclamation.

CONTENTS

Page

Foreword i
Acknowledgement iii
Introduction 1
Setting 3
  Water in the West today 3
  Key factors which will influence future Western water resource conservation and development 5
Westwide problems and issues 9
  Water for energy resources development 9
  Water for small communities 11
  Water for Indian reservations 12
  Water for public lands 13
  Water from conservation and reuse 14
  Water from weather modification 16
  Water pollution and urban waste water management 19
  Increasing salinity in major river systems 21
  Erosion and sedimentation 22
  The environmental data gap 24
  Wild, scenic, and recreational rivers 26
  Wilderness areas 28
  Flat water recreation 29
  Federal assistance to irrigation 30
  Coordinated land use and water planning 32
  Flood plain management 33
Regional problems and issues 35
  Colorado River salinity 35
  Colorado River water supply 38
  Lower Colorado River main stem management 45
  Oil shale development in the Upper Colorado region 47
  Total Water Management of the Columbia River system 49
  The Columbia River estuary 51
  Middle Snake River Canyon 52
  Erosion of the Palouse area 54
  Anadromous fisheries in the Northwest 56
State problems 58
  Arizona 58
  California 60
  Colorado 63
  Idaho 65
  Montana 67
  Nevada 68
  New Mexico 70
  Oregon 71
  Utah 74

CONTENTS – Continued

Page

- Washington 76
- Wyoming 78

Potential investigations 80

General observations 81

The study years ahead 85

INTRODUCTION

In September of 1968 the Congress, as part of the legislation authorizing the Colorado River Basin project, directed that the Secretary of the Interior shall "conduct full and complete reconnaissance investigations for the purpose of developing a general plan to meet the future water needs of the Western United States." The act defined Western United States as the 11 coterminous Western States. A final reconnaissance report to be submitted to the President, the Congress, and the Water Resources Council no later than June 30, 1977, was specified. This report is in response to these directives.

Investigations leading to this report were initiated in 1970. The Westwide Study was carried out under the direction of a full-time management group in Denver, Colorado, headed by the Bureau of Reclamation. In this group, all affected Federal interests were represented. Close cooperation with the States was maintained at all times and much of the planning activity was accomplished by State-Federal study teams which were established for each State. An advisory committee composed of representatives from many related fields of natural resources provided a forum for exchange of ideas and public involvement in the conduct of the study.

The Westwide Study was designed initially (1) to produce a general plan to meet the future water needs of the 11 coterminous Western States, (2) to be interdisciplinary in character reflecting views and objectives of economic, engineering, social and environmental concerns, and (3) to be interagency in participation and direction involving all affected Federal agencies, the 11 States, and private and local interests. The schedule called for completion of investigations and submission of a final report in June of 1977.

The wide scope of the Westwide investigation as outlined in the initial and subsequent plans of study was questioned intermittently by various interests within the States, the Administration, and the Congress. Subsequent to the authorization of the Westwide investigation in 1968 the Water Pollution Control Amendments Act of 1972 (Section 209) directed the President, acting through the Water Resources Council, to prepare water resource plans by 1980 under the Water Resources Planning Act for river basins throughout the Nation, which, in the West, could well be considered duplicative of the initial Westwide endeavor. In light of these factors, a decision was made to terminate field work on the Westwide investigation by July 1, 1974, and to prepare a report based on data and information available at the time.

The consequent shortening of the study period by three years precluded the attainment of the original objectives of "full and complete reconnaissance investigations" for developing "a general plan to meet the future water needs of the Western United States." The study did, however, pioneer in several new concepts of water study management. In doing so it accommodated, in greater detail and specificity than any comparable previous study, the interagency, the interdisciplinary, and the State-Federal aspects of water resource planning. Specifically it illustrated:

1. That coordination of major water resources investigations is not properly a part-time job for designated personnel. Rather, the full-time active involvement of a management group representing wide and diverse interests is required.

2. Within the present structure of Federal Government, all Federal agencies with a legitimate interest must be involved.

3. All of the interests and disciplines impinging on or affected by water resources programs, be they Federal, State or local, must be adequately represented.

4. State views and aspirations must be represented and reflected.

5. The views of all other concerned interests must be taken into account.

With curtailment of studies, it was not possible to present a general plan to meet the future water needs of the Western United States. Instead this report concentrates on presenting:

1. Findings and conclusions reached to date. In some instances these findings and conclusions are based on the objective judgment of the study participants due to lack of completed detailed investigations.

2. A description of the major water resource problems facing the West.

3. Suggested alternative solutions to some of these problems where apparent.

4. Steps necessary to resolve these problems including future investigations, with emphasis on action required in the 1976-1985 period.

This Executive Summary is supported by a comprehensive report which presents in detail the results of the Westwide Study. Generally the summary follows the outline and content of the report and presents in concise terms the highlights and significant conclusions and recommendations of the report.

The major contribution that this report can make is to define and influence the scope and character of future Federal and State water resources investigations of the West through the year 1985. The present and near future critical water resources problems and issues of the West are clearly outlined herein. There are no simple, direct, permanent solutions to most of these problems and issues. Nor will there ever be. The World, the Nation, and both contemporary and long-term values change too rapidly. Only continuous study and evaluation will provide the proper guidelines. In this respect the Westwide effort assembled an impressive team of Federal experts in the widely varying disciplines of water resources matters. It involved also in impressive intensity State-Federal cooperation in water resources studies. From these sources hopefully will come a solid guide to water resources investigations in the West for the next decade for both Federal and State interests.

SETTING

The major thrust of this report, then, is to identify the critical, unresolved water problems of the West, together with suggested steps to resolve them. Important to the understanding of these water problems is the setting in which they occur and in which they will be resolved.

Water in the West Today

In virgin or undepleted conditions it is estimated that the average annual surface runoff or yield of the stream systems of the 11 Western States aggregated 427 million acre-feet including 50 million acre-feet of inflow from Canada. Today, due to the cumulative activities of man, this virgin water supply has been depleted by 83 million acre-feet of consumptive water use annually leaving 344 million acre-feet or about 81 percent of the virgin yield still not consumed. On its face this appears to be ample to meet the consumptive water needs of the West far beyond the foreseeable future. As a practical reality, however, these statistics only demonstrate that it is hazardous and misleading to generalize about water supply and water resources for a region as large as that encompassed by the 11 Western States.

Within this western region are large areas such as the Upper Rio Grande and the Gila River basins where the total annual surface water supply, for all practical purposes, is completely consumed. In the Colorado River Basin this condition will be reached when the Central Arizona project is completed. After that, as the Upper Basin expands its water consumption under its Colorado River Compact allotment, uses in the Lower Basin will have to be curtailed

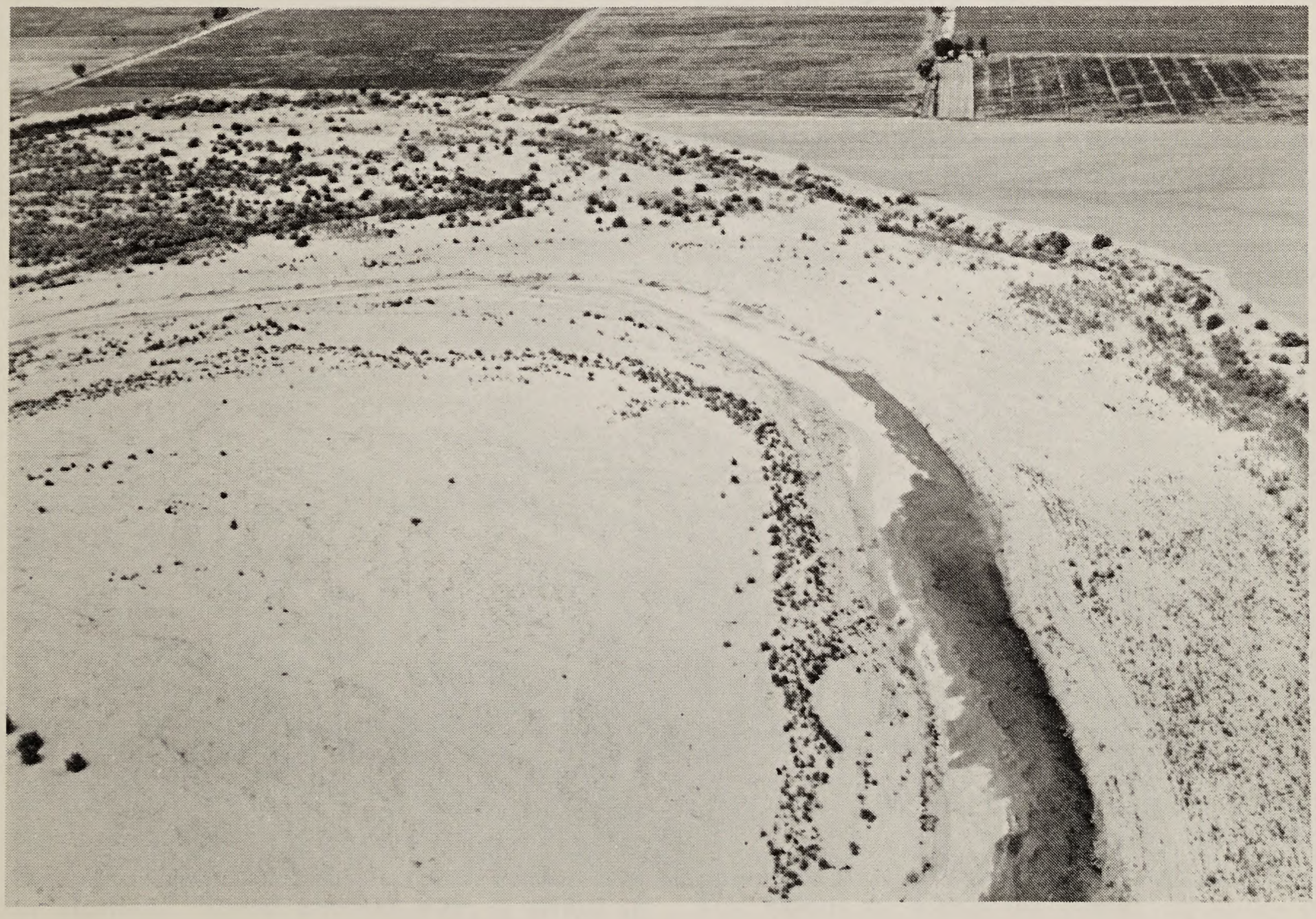


Figure 1. Colorado River vanishes in Mexico 700 miles below Lee Ferry.

due to limitation of water supply unless the natural supply of the Colorado River is augmented. In the Arkansas-White-Red and the Great Basins, it is forecast that by the year 2000 the total water supplies essentially will be utilized.

The Missouri River and its tributaries in Montana and northern Wyoming appear to have sufficient unused water supplies to meet needs for the foreseeable future; however, as consumptive water uses increase there will be an effect on hydrogeneration capabilities of the Missouri River main stem and there may be an effect on the lower Missouri River navigation project. The Platte River tributaries in Wyoming and, particularly, in Colorado are approaching the saturation point in water use. California generally appears to have ample resources of water for its future needs but the areas of supply do not match areas of demand, necessitating the long-range water transfer works that now serve major areas of the State.

Even in those areas such as the Pacific Northwest that are blessed with large surface runoffs, nonconsumptive use requirements for water such as hydroelectric power are such that actual water shortages can and do occur. It is somewhat paradoxical that in the Columbia River basin, which discharges some 180 million acre-feet of water annually into the Pacific Ocean, weather modification programs have been carried out to augment the runoff in the Flathead River tributary for power production purposes.

Ground water is an important source of water supply in the 11 Western States. It is estimated that 6.2 billion acre-feet of water are in storage at depths ranging from 50 to 200 feet. In certain areas such as central Arizona, the high plains area of New Mexico, several sections of the San Joaquin basin in California, and the southern California coastal area, ground water is being mined to the extent of creating major problems. Generally, however, the ground

Figure 2. Columbia River near its mouth.

waters of the West are not being utilized optimally due to lack of sufficient information as to location, quality, physical characteristics and costs to develop, and policies as to their use. Much remains to be done to bring about the best conjunctive development and management of surface- and ground-water supplies.

Key Factors Which Will Influence Future Western Water Resource Conservation and Development

The past decade has witnessed more and greater shifts in policy and emphasis in water resources conservation and development than any period in history. The effects of these shifts are just beginning to show and will not be fully reflected until many years in the future. Still other shifts and influences are on the horizon and are predictable today. Some of these factors apply nationwide; others to the West alone. To the extent that such factors can be identified and evaluated they must be taken into account in the effective planning of water resources conservation and development for the future.

Population and Related Growth. – A westward movement of the Nation's population has been underway since the days of the Founding Fathers. This together with natural fertility rates has produced population growth rates in the West much higher than for the Nation as a whole. Even with a decline in the rate of national population growth there is every indication that this relationship will continue, particularly since the major factor in western growth has been immigration. The latest Bur- of Census projections based on assumptions of zero population growth (ZPG) indicate that through the year 2000 the population of the 11 Western States will increase at a rate more than twice that of the rest of the Nation.

What this rate of growth means for the West is that every year between now and the year 2000 the West will experience a population increase equal to the 1970 population of Idaho or Montana. Stated another way, it means an addition equivalent to one new city of 65,000 people every month through the year 2000 even with ZPG projections.

Growth rates will not be uniform, however, as the projections for some States such as Idaho, Montana, and Wyoming, forecast quite modest population increases while for others, such as Arizona and California, populations by the year 2000 are expected to double and in Nevada to almost triple. In addition the population growth will occur exclusively in metropolitan areas. By the year 2000 it is projected that 90 percent of the West's population will reside in metropolitan areas – areas where a contiguous population exceeding 100,000 exists – as compared to 83 percent for the rest of the Nation. The result of increasing urbanization will be that the future West will continue to consist of vast reaches of sparsely populated land interrupted occasionally by large metropolitan areas.

The expected population growth will provide labor for industrial growth and will create increasing demands for manufactured goods, services, and food. All of these growth factors translate into increasing requirements for domestic, industrial, agricultural, and recreational water, and for land.

The Energy Production Potential of the West. – The Western States contain most of the undeveloped energy resources of the United States. Over 70 percent of the country's strippable coal reserves are found west of the Mississippi River and most of these are in the 11 Western States. Most low-sulfur subbituminous coal and lignite resources are concentrated here. Most of the former are in Montana and Wyoming. Oil shale deposits in Colorado, Utah, and Wyoming are the richest in the world containing an estimated 600 billion barrels of extractable oil, enough to supply the Nation's oil needs for 100 years at current rates of use. The major uranium reserves of the country are also found in the Rocky Mountain States. Important geothermal energy resources are also found in the West.

The extent to which the energy resources of the West will be developed to realize the stated national objective of attaining self-sufficiency in energy production by 1980 is as yet unknown. Whatever this may prove to be, the resulting demands on the West's energy resources plus those required to meet any reasonable projection of energy needs for the western area itself are certain to present varied and complex problems involving western water quantity and quality in the future.

Environmental Quality. – The impacts of the tide of Federal and State legislation of recent years reflecting the surge in national concern over protection of environmental values are just beginning to be reflected in water resource conservation and development programs. The public has and is still demonstrating a willingness to sacrifice some developmental and economic growth opportunities to protect and enhance certain aspects of environmental quality.

The degree or extent to which certain goals of environmental quality will be achieved is not yet clear. However, trends are clear. It is certain that:

The Wild, Scenic and Recreational Rivers Systems will be enlarged;
Wilderness, Primitive and Natural areas will be expanded;
Park and Recreation areas and facilities will be enhanced and increased; and
Greater attention will be given to protection, enhancement and management of fish and wildlife resources, including protection of endangered species.

These and other activities related to environmental values will all impact on water resource programs of the future.

A special category of environmental concern is that related to protecting and improving the quality of the Nation's waters. Attainment of the water quality goals set forth in Federal water pollution control legislation will require an unprecedented commitment of funds and manpower as well as some major changes in water management programs. Substantial progress is being made and will continue to be made toward meeting those goals with widespread influence on the emphasis and character of future water resource programs.

Land Use. – Land use policy, as evidenced in proposed legislation considered by the last two sessions of the Congress and in legislation already passed or under active consideration in a number of States, reflects an emerging national concern as to appropriate land use. The focus of concerns is upon (1) urban land use; (2) the location of key facilities, such as airports, highways, major housing subdivisions, which will significantly alter land use patterns; (3) the designation of areas of critical environmental concern; (4) the preservation of valuable resources areas for agricultural, forestry, and mineral production; and (5) flood plain management.

The future water programs of the West of necessity will be oriented to meet the needs of land use plans. Because of the high concentrations of federally-owned lands in the West, there will be a special need to define carefully the character of the Federal role in water and land planning for the 11 Western States.

Indian Water Rights and Requirements. – There are 172 Indian Reservations in the 11 Western States which comprise 12 percent of the private lands and on which reside 1 percent of the population of those States. The importance of Indian-related water resource problems is far greater than the relative population statistics would suggest.

The great need for the majority of the Indians is to improve their economic status. With that will come enhancement of their educational, social, health, and other factors leading to a higher standard of living. Based upon recent data, in the 11 Western States the median family income of the Indian is $4,293 compared to $9,126 as an overall average; unemployment is 45 percent for the Indian compared to 6 percent Westwide.

There are significant opportunities for development of agricultural, industrial, energy, recreational and other economic activities on Indian reservations throughout the West that, if realized, could improve the economic status of the Indian tribes tremendously. Most of these opportunities will require additional water. There is no question that, as a whole, there is additional water available for use on Indian reservations. There is question in many instances as to the extent or amount of water to which the Indians are entitled. Resolution of these uncertainties will require Federal or State court decisions which may be many years away. Although it is difficult to predict the specific rulings in the many facets of Indian water rights court proceedings, it seems likely that through some means water to meet water requirements for Indian reservations will become available.

Irrigation Development. – It is unquestionable that federally sponsored irrigation has played a significant role in both the economic and water resources development of the West. There is question, however, as to what role it will play in the future. In major portions of the West the historical stimulus that irrigation development has given to economic growth is no longer needed. In other areas it is. Available projections of future food and fiber needs to be met by irrigated agriculture especially where worldwide needs are included, present a cloudy picture at best. The social advantages of maintaining rural populations and the family-sized farm are being reevaluated.

The net result of these developments and considerations, combined with a growing competition of other programs for the Federal dollar, has been a slowdown of the Federal irrigation program over the past few years. Future national policy on federally supported irrigation development can have a major impact on water resources conservation and development in the West.

Total Water Management. – With a number of western river basins having reached or rapidly approaching full utilization of their water supplies, planned improvement in total water management to meet current and future demands is gaining more and more attention. Total water management embraces both quantity and quality aspects. It involves conservation and improved efficiencies in water use, coordinated scheduling of river basin water storage and control works, salvage and reclamation of poor quality supplies, conjunctive use of surface and ground waters, reallocation of water supplies to higher uses, and all other such practices that promote the fullest and highest uses of a basin's water supplies. For the total water management concept to be successful it is essential that the local, State, regional, and national entities involved in a basin or area's water planning, conservation and development programs work in close cooperation. It is expected that total water management increasingly will become a most important means of satisfying new water demands in the West.

Changing Trends in Water Resource Planning. – In addition to the physical, economic, environmental, and institutional trends that are affecting and will further affect water resources conservation and development in the future, there are significant trends in water resources planning that are certain to have profound impacts. As the available water supply of the Nation and the West becomes more and more committed, water resources planning becomes more complex and of more immediate and long-range concern to a wider body of interests. This has led, and properly so, to the involvement of more and wider disciplines and public interests in planning. This has resulted in a slowdown of the planning process but should produce better and more responsive plans.

New techniques in planning are emerging. Among these are the more sophisticated and complex forms of modeling, using computers to simulate physical, economic, social and environmental conditions and to evaluate impacts and trade offs. Multi-objective planning, with economic and environmental objectives receiving equal or commensurate emphasis, and with social and other factors receiving greater consideration, is coming to the fore.

The whole issue of cost sharing for water resources conservation and development programs is undergoing examination and reevaluation. The recommended changes for non-Federal cost sharing in Federal water resources programs contained in the recent report of the National Water Commission were probably the most sensitive and controversial that the Commission made. They reflect, however, a growing national realization that greater cost sharing by local and State beneficiaries should be expected in the future.

Finally, much greater participation by State and local interests in the planning and accomplishment of water resources programs is in evidence. While this is particularly true for most Western States, certain States such as California, have had for many years aggressive and competent water resource planning and development agencies.

Problems and Issues. – The remainder of this report addresses itself to the critical water resources problems and issues facing the West. While no instant resolutions or panaceas are offered, a program of investigations is recommended for the next 10 years which reflects the deliberation of a group of highly qualified State-Federal water resource experts. Only through such consideration can the water resource problems and issues of the West be best resolved.

WESTWIDE PROBLEMS AND ISSUES

The major water and related resource problems and issues of the 11 Western States are, in general, common to all 11 States, differing only in extent or degree of seriousness. The Westwide Study effort identified a number of such problems and issues, some of which overlap. They fall into four broad categories – water supply, water quality, environmental, and other.

The water supply problems include: water for energy resource development, water for small communities, water for Indian reservations, water for public lands, water from conservation and reuse, and water from weather modification. The water quality problems cover: water pollution and urban waste water management, increasing salinity in major river systems, and erosion and sedimentation. Environmental problems encompass: the environmental data gap; wild, scenic, and recreational rivers; wilderness areas; and flat water recreation. The other problems relate to: Federal assistance to irrigation development, coordinated land and water use planning, and flood plain management.

Water for Energy Resource Development. – The future of energy resource development in the West depends upon the response to a two-fold demand. First, the resource must meet the burgeoning energy demands of the West itself. Beyond that the resource has the potential for meeting a significant share of the future energy needs of the Nation. Thus the rate at which the energy resources will be developed depends largely upon the contribution that western energy resources will make to meet national energy needs.

The role of western water in meeting high-priority energy needs is tied primarily to the mining and processing of large reserves of coal and oil shale, to waste heat disposal from

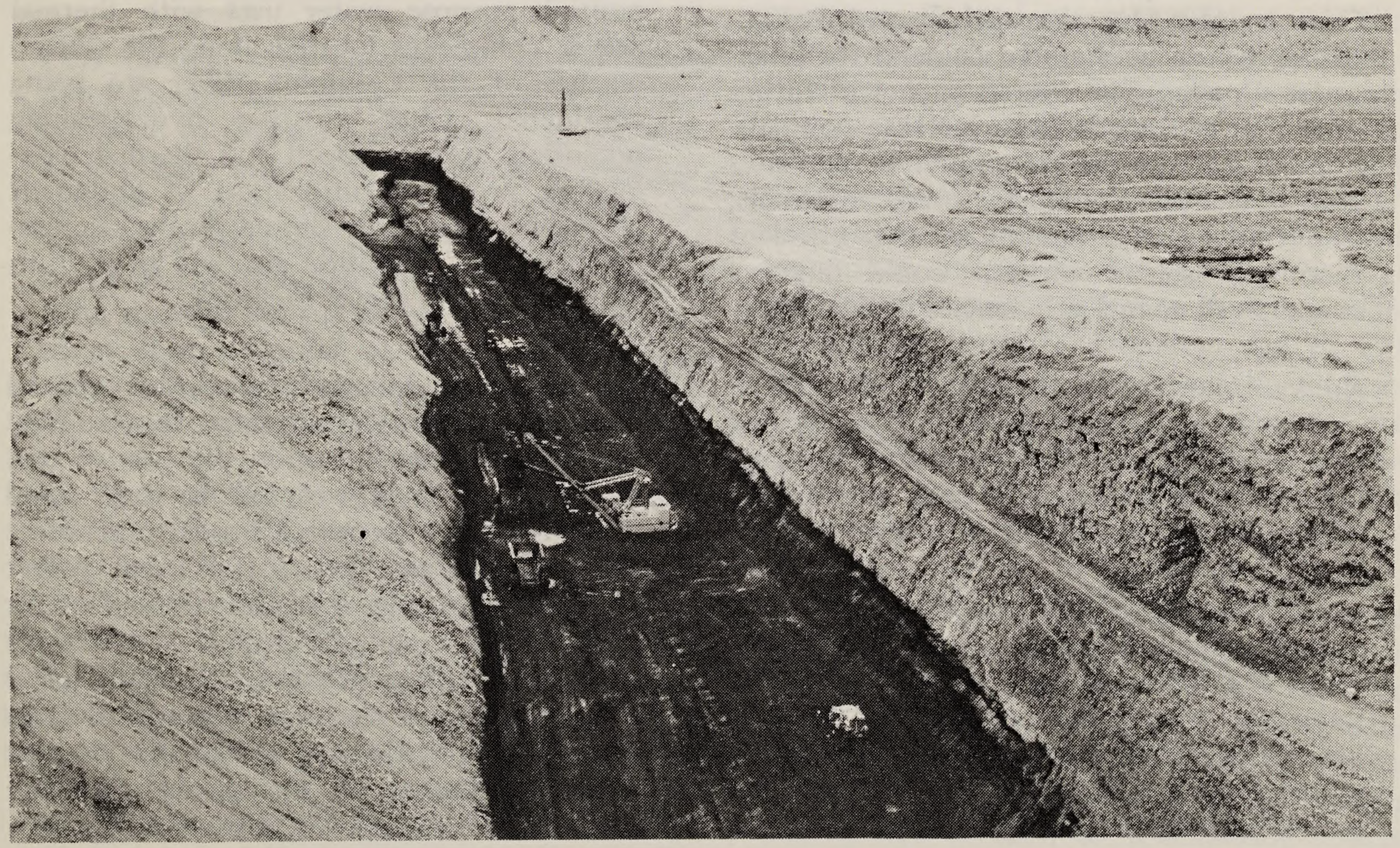


Figure 3. Strip mining a 52-foot-thick coal seam in Montana.

thermal electric and fuel conversion plants, to supplying municipal growth directly associated with fuel production, and to providing hydroelectric peaking capacity. Because some of the mineral energy wealth is located near or in areas involving national assets of high environmental value, there will be a need for judicious and timely water and related land planning.

In the United States, overall energy use may triple by the year 2000. Even if a more conservative growth pattern is assumed, the enormity of the related problems to be faced in the foreseeable future does not change significantly. The problems simply move forward on the overall time scale in the latter part of this century.

The western picture by regions is as follows:

> *Pacific Southwest.* – The pattern of fossil-fired thermal plants and coal development is expected to continue, supplemented by nuclear power installations. As a result of recent State legislation, a major shift in siting thermal plants from the South Pacific Coast to inland locations is expected, accompanied by an accelerated demand for freshwater supplies. The overall impact of future power development is to increase competition for a limited water supply. Several sites with outstanding pumped-storage potentials, if developed and combined with efficient thermal baseload plants, could improve overall system fuel efficiencies in the future.
>
> *Rocky Mountain and Northern Great Plains.* – The key energy resources of strippable coal, uranium, and oil shale, accompanied by low energy demands in the area, might make this region a major energy export center. The transportation of electric energy or coal and oil shale products out of the region is one of several alternative futures. Available water supplies are not always located in the immediate vicinity of energy resource areas; hence, interbasin water transfer, exchanges, ground-water use, or conversion of established water use may be required. Water availability in adequate quantities to support a regional energy export center is dependent on location of energy resource (Colorado or Missouri drainage), varying State water quality criteria, water rights, advance energy conversion technology, and potential improvements in cooling techniques. There are some potentials for hydroelectric power production, both conventional and pumped storage, but most sites involve conflicting uses.
>
> *Pacific Northwest.* – The major expansion of power facilities in the Pacific Northwest is expected to be in baseload thermal powerplants, with increasing reliance on nuclear installations. Increased imports of energy in the form of fossil fuel or electricity from adjoining States, primarily Wyoming and Montana are also expected. As existing hydroelectric capacity is shifted from baseload to peaking service, the addition of units at existing hydroplants is a logical step which should generally meet peaking requirements for the next 15 years or so. With its adequate water resources, the major problems most likely will involve environmental concerns. The combination of multiple-purpose water uses with thermal power complexes located along the central reaches of the Columbia River are being considered. Once existing hydropeaking potentials are developed and thermal baseloading provided, utilization of abundant pumped-storage sites should receive increasing attention. Attention also will be given to thermal peaking power facilities.

The overall requirements for freshwater related to energy resource development in the West will, of course, depend upon the rate of that development. By the year 2000, they could very well amount to over 3.3 million acre-feet – 2.5 million acre-feet for thermal power cooling requirements, 0.6 million acre-feet for coal gasification, and .26 million acre-feet for oil shale processing. Where such consumptive water requirements occur in water-short areas they may be met through a shift in water use or water import.

Future development of offshore powerplants that use ocean water as a heat sink, waste water cooling, extensive water recycling, and beneficial use of waste heat are expected to alleviate some of the pressure on freshwater resources. Use of hot-water effluents for aquaculture, deicing, sewage treatment, space heating, and warm-water irrigation remain as concepts to be evaluated for technical and environmental feasibility. Also, the increased use of low-quality return flows and of ground water in remote areas may help conserve better quality surface supplies.

In addition to the water supply problems created by energy resource development there are associated water quality problems. Cooling water discharged from fossil-fueled powerplants must meet thermal pollution standards.

Another less obvious yet important effect on water quality results from consumption of water through evaporative cooling. Although consumptive use in cooling systems without return flows effectively removes everything including salts from a river system, the net effect is usually increased salinity concentrations downstream.

Coal mining, coal conversion, and oil shale development for energy production all have potential to degrade water quality in the West. Strip mining may disturb patterns of drainage, surface water runoff, and ground-water aquifers unless there is adequate advance planning and implementation of effective controls. Also, damage can occur to surface and ground water from disposal of poor-quality ground water encountered in mining and from possible additions to pollution from processing.

In view of the increasing national concern relating to meeting future energy requirements there is an urgent need for early determination of where the development of western energy resources fits into the picture, what arrangements should be anticipated to meet associated water quantity and quality requirements, what steps should be taken to preserve environmental values, and, in general, how the vast energy reserves of the West can be developed in the best interests of both the Nation and the West.

Water for Small Communities. – There are 6,500 nonmetropolitan communities in the 11 Western States. At least one-quarter of them have water in short supply, water of poor quality, or both. The range of physical problems includes lack of supplies, mineralized supplies, inadequate storage and treatment facilities, and deteriorating distribution systems.

National policy enunciated in the Rural Development Act of 1972 states that adequate water supplies should be provided for economically distressed communities to aid in their efficient and orderly growth. Without some outside financial and technical assistance many of the western communities cannot be expected to solve their water supply problems. They thus will face further decline in economic activity and public welfare.

Various State and Federal programs provide assistance to small communities to resolve their water supply problems. Some states provide technical as well as financial assistance while others offer only a minimum of technical assistance. Federal agencies that provide technical assistance and funding through authorized programs include the Economic Development Administration, Department of Housing and Urban Development, and the Farmers Home Administration. Each of these agencies provides aid under widely varying criteria covering population, unemployment and income levels, and other factors. Assistance is also available through the Rural Development Act of 1972 but not yet fully implemented. In addition, multipurpose water resource development projects of the Soil Conservation Service, Corps of Engineers, and the Bureau of Reclamation may include water supply to small communities.

A review of current programs should be undertaken by a State-Federal group to ascertain their effectiveness toward meeting water supply needs for small communities and to determine the adequacy of funding levels, effectiveness of qualifying criteria, ease of obtaining aid, needed revision of cost-sharing policies, and responsiveness to community needs. Thereafter, the states would appear to be the logical

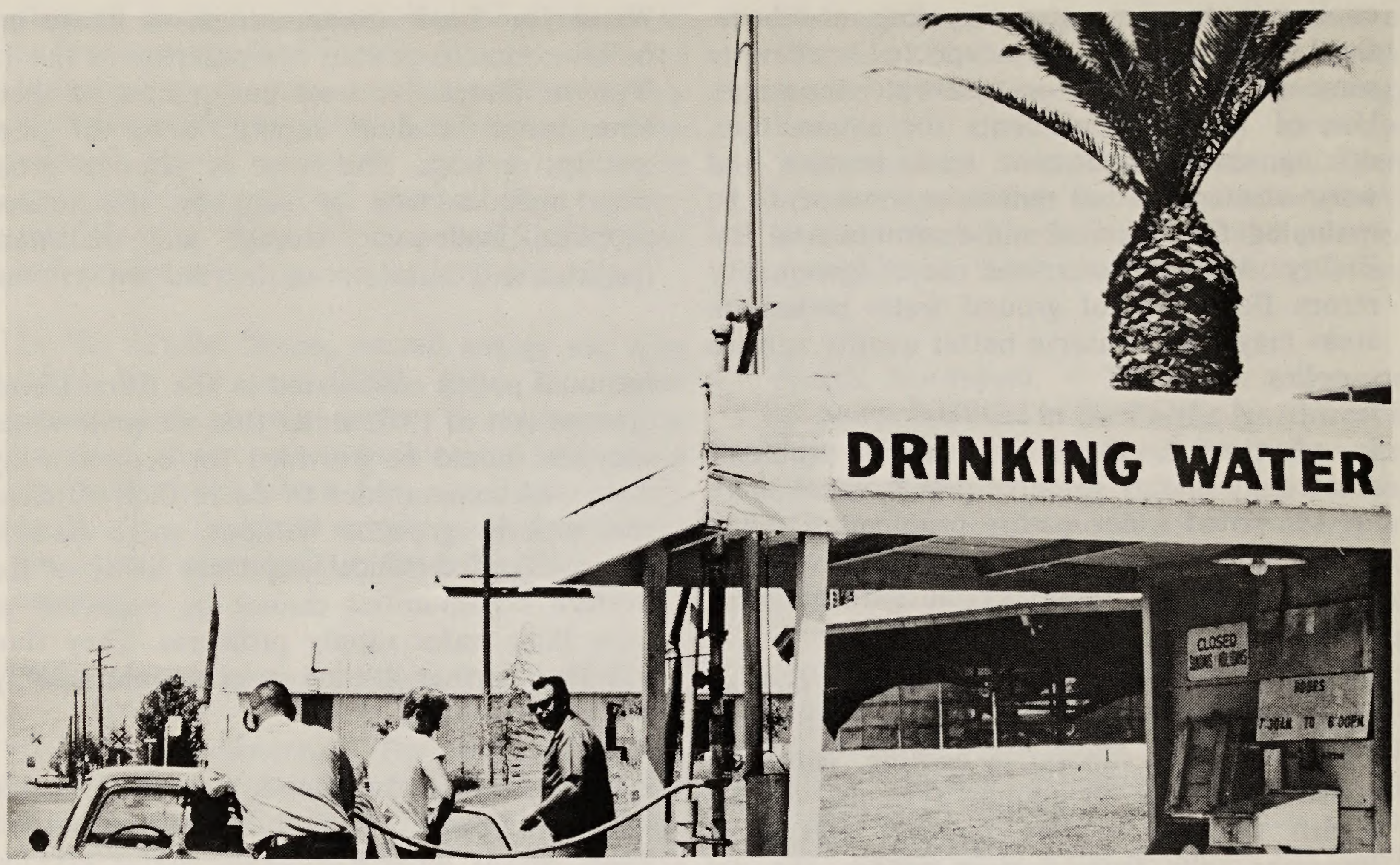


Figure 4. Coalinga, California, obtains its drinking water from two desalting plants.

entities to appraise the needs of the individual communities for assistance and to take the lead in arranging such assistance from the most appropriate source.

Water for Indian Reservations. – Because of Federal commitments and responsibilities related to the Indians the development of resources on the 172 Indian reservations in the 11 Western States poses a special problem. The overall Indian problem is one of a very low standard of living – economic, social and otherwise. The median Indian family income of less than one-half that of the 11 State average and an unemployment rate of over 7 times the average attest to this.

Two presidents in recent years have forcefully called attention to the Indian problems in messages to the Congress. President Johnson stated "With rare exceptions, Indian communities are so underdeveloped that there is little, if any, opportunity for significant social or economic progress * * * our goal must be: A standard of living for the Indian equal to that of the country as a whole." President Nixon in his message of July 8, 1970, stated, "The first American – the Indian – is the most deprived and most isolated minority group in our Nation. * * * our Government has made specific commitments to the Indian people. For their part the Indians have often surrendered claims to vast tracts of land and have accepted life on Government reservations. In exchange the Government has agreed to provide community services – services which would presumably allow Indian communities to enjoy a standard of living comparable to that of other Americans. This goal, of course, has never been achieved."

An important key to improving the economic and social standing of the Indians is the development of the natural resources of the reservations which include vast reserves of oil, gas, and coal, millions of acres of potentially productive farmland, and recreational opportunities. At virtually all of the established

Indian reservations in the 11 Western States the quantity and quality of water readily available determine the degree to which these natural resources can be developed and utilized.

In some areas there are adequate water supplies to accommodate both Indian and non-Indian development needs. In such areas the obvious solution is to appraise the potential for resource development, establish the related water needs, and select and initiate those programs which will best benefit the Indians.

In water short areas, however, where there are competing demands for water, obtaining adequate supplies of water for Tribal needs will, at best, be difficult. In many instances the Indian's entitlement to water will turn on future court decisions which may be years away.

The controversies over Indian water rights are well known and long standing. They will not be reviewed here, except to note that in the Winters Decree, a benchmark case in establishing Indian water rights, the courts ruled that the Ft. Belknap Tribe in Montana had a legal right to utilize waters originating on, flowing through and/or adjacent to their reservation to support a viable economy on Tribal lands. A key issue, however, as yet not clearly resolved by the courts, is the Indian position that since the purpose of the Indian reservation is to provide an economic base for the Indian people residing thereon, it must follow that the Indian water right is a right to use the available reservation waters for any beneficial use including irrigation, livestock, domestic, power, recreation, industrial, and municipal purposes, and the maintenance of instream flows to protect biotic and esthetic values inherent in reservation and related systems.

Regardless of the outcome of future court cases, it is essential that the present and future water requirements of the Indian reservations be identified before Indian water rights can be legally dimensioned. It has been only within the past year that a comprehensive program has been initiated by the Bureau of Indian Affairs to quantify water supplies and requirements for Indian reservations in the West. The investigations to date have been limited to 20 of the 172 reservations. To ensure that the necessary analyses and evaluations are forthcoming and that effective resource development programs can be instituted in a reasonable period, the present level of investigation activity must be substantially expanded.

Where water supplies are clearly available the Federal Government should press forward with whatever studies and analyses are required to define and initiate appropriate resource programs to benefit the Indian tribes. Where water supplies and water rights are in contention or litigation, and thus effectively blocking Indian resource development, the Federal Government should be diligent in providing whatever assistance it can which will lead to early resolution of such controversies, followed up with appropriate resource development programs.

Water for Public Lands. – The vast public land holdings of the United States in the West give special importance to the problem of insuring the availability of adequate water supplies for their wisest and best use. There are 356,000,000 acres of public lands in the 11 Western States, 47 percent of the total land area. Public lands range from 29 percent of the total land area of the States of Montana and Washington to 86 percent of Nevada. The Bureau of Land Management and the Forest Service are the largest Federal land management agencies in the West. Together they manage about 315,000,000 acres. In addition, the National Park Service, the Fish and Wildlife Service and the Department of the Defense all manage public lands in the West.

The consumptive and nonconsumptive needs for water on public lands have never been fully documented. Unless such water requirements are established, it will become increasingly difficult to provide for the optimum use of the lands.

Of particular importance at this time is the fact that the current national energy shortage has renewed interest in increasing energy production through the use of the extensive mineral resources of public lands. Priority consideration is being given to the use of coal, oil shale, and geothermal resources found throughout the West. Urgent and critical energy requirements have raised questions about the responsibility of the Federal Government to provide or reserve water for development of the mineral reserves located on both public and on private lands where the Federal Government has reserved mineral rights. The Federal Government has placed the responsibility for obtaining these water rights on the entity that develops the energy resource.

Water on public lands is required also for such broad needs as improving the forest environment and providing sustained timber yields; livestock grazing; wildlife and fisheries conservation and management; recreation, domestic, municipal, and administrative site consumption; firefighting and fire prevention; wilderness preservation; flood and soil erosion control; and preservation of aesthetic and other public values.

An accelerated program is needed to describe water requirements for public lands and to obtain recognition of those requirements in Federal and State water law and administrative arrangements. To this end the Federal agencies having land management responsibilities should complete efforts to document by 1980 the water requirements for current and future uses on public lands.

Water from Conservation and Reuse. – As the waters of the West are more and more committed and put to use, the potentials of meeting water demands through water conservation and reuse become more and more important. This is particularly true in areas of present or imminent water shortages such as the Rio Grande and Pecos River basins, the Colorado River basin, the Front Range region,

Figure 5. Harvest from land of Navajo Indian Irrigation project, New Mexico.

the Wasatch front area, the Arkansas River basin, the Carson and Truckee River basins, and other spot areas throughout the West. Evolving technologies plus the requirements for treatment of waste waters under water pollution control legislation are giving further impetus to meeting water demands through conservation and reuse. Inasmuch as irrigated agriculture accounts for over 80 percent of the water depletions in the West today, the promotion of greater efficiencies in irrigation water use holds major promise as one means of stretching short water supplies. There are also significant potential savings in municipal and industrial water use, as well as potentials for increasing natural runoff by various means.

Irrigated agriculture consumes almost 70 million acre-feet of water annually in the 11 Western States. Of this amount about 50 million acre-feet are consumed by growing crops. The remaining 20 million acre-feet are consumed as a result of losses in the irrigation process. Much of this loss is consumptive use by vegetation, which is often beneficial for wildlife habitat and aesthetic purposes. Nevertheless, there is opportunity to conserve a significant part of the 20 million acre-feet lost and still accommodate environmental objectives.

The concept of "productivity increases," long used with regard to labor and land, should be applied to water. In irrigation, where water is scarce or a limiting factor in farming, operation should be such as to maximize the output of agricultural products per unit of water use. Means to accomplish this include lining of conveyance and distribution systems, more exact timing of water deliveries, avoidance of overdeliveries, use of new water savings methods of irrigation such as drip irrigation,

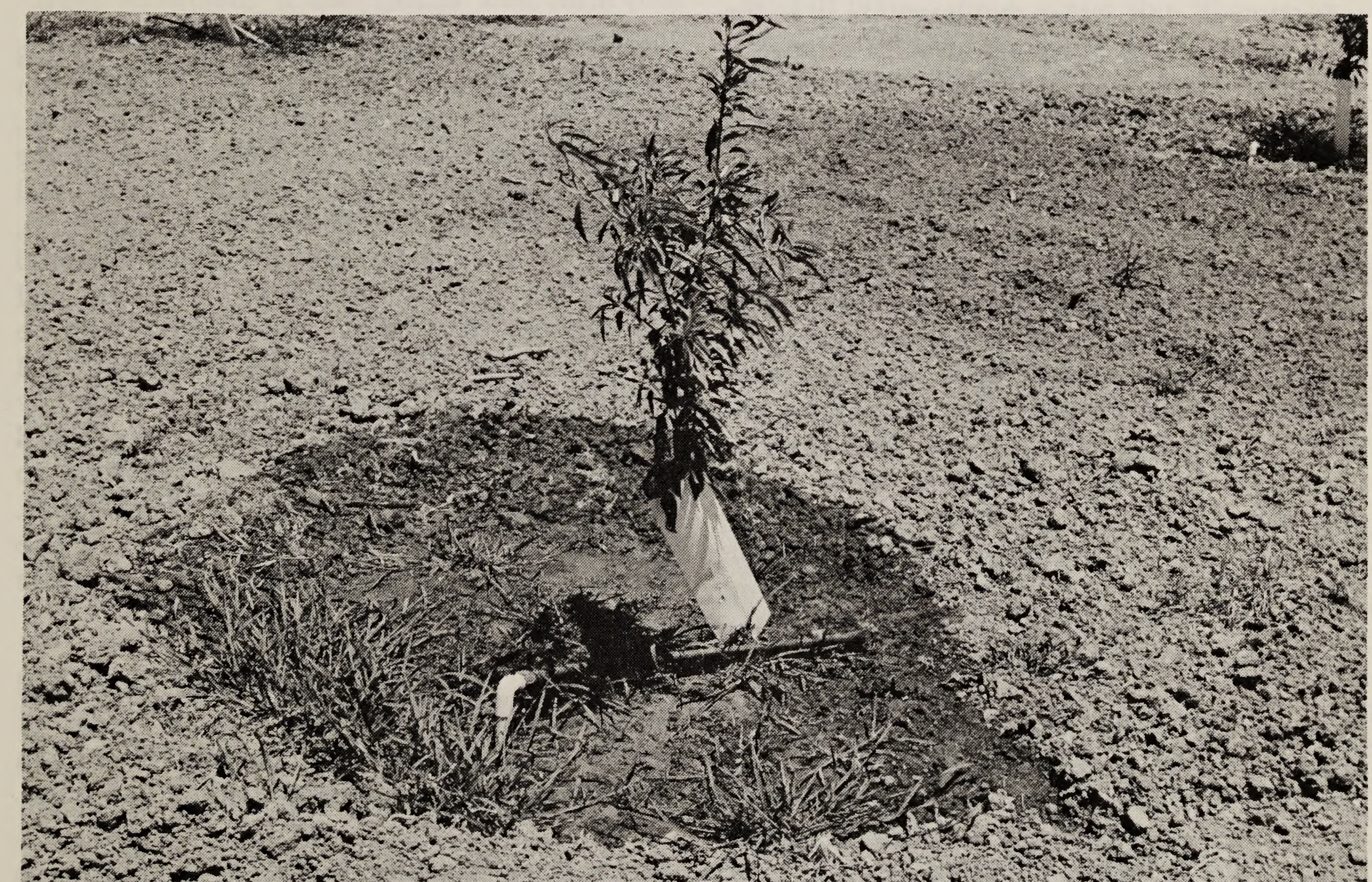


Figure 6. Drip irrigation saves water.

and overall better management of irrigated agriculture. Such practices where feasible would not only improve water supplies but would promote better water quality in the streams receiving irrigation return flows.

Municipal and industrial water uses, although not relatively large consumptively, are significant and are often a source of water quality degradation. Reuse or successive use of diverted water for municipal and industrial, electric power cooling, and mineral production purposes may not change the total amount of consumptive use but will reduce diversions and may have a favorable impact on water quality. A reduction in consumption in these types of uses will probably require a change in the characteristics of use. Urban area design could emphasize the use of grasses and shrubs which thrive in semiarid or arid conditions in place of irrigated lawns and parks. Open space does not have to be green to be useful and attractive. A reduction in unit water requirements in industrial and cooling processes usually requires a change in the industrial process itself; more air cooling in place of water cooling for example.

The role of changing technology in conservation and reuse of water is varied and complex. Application of available technology could increase the output of goods and services per unit of water used. The major alternatives in power production will tend toward water conservation. Gas-cooled nuclear reactors and nuclear fusion operations are two cases in point. In fossil-fuel generation there is the possibility that dry cooling systems may replace more conventional evaporative cooling systems as new plants are built. Such a system is being installed at the Wyodak plant now under construction at Gillette, Wyoming.

Increases in water yield through vegetative management have been demonstrated through research. In the West increase potentials exist on forested and associated brush and range lands. Even though a potential exists there is need for information on total cost and environmental impacts before effective large-scale water-yield improvement programs can be initiated with predictable results. A major challenge in the future will be to find ways to bring the diverse management objectives of public and private lands and the specific interests of the downstream water users together into a mutually beneficial multipurpose management program. Recent estimates indicate that potential increases in water yield in the West are 4 million acre-feet annually. The cost of water development through vegetative management varies widely but for the West is estimated to average a little over $20 per acre-foot. This represents an economic means of helping to meet future water requirements in the West.

Suppression of reservoir evaporation by application of fatty alcohol monolayer films to reservoir water surfaces is a physical possibility although research to date has not been able to solve the problem of wind destruction of the evaporation inhibitive film layer. Water saving by this method would be economical only in areas where water costs are quite high.

There are a number of Federal agency ongoing research programs aimed at the conservation and reuse of water for agricultural, industrial, and other purposes. These programs, including those of the Agricultural Research Service, Soil Conservation Service, Bureau of Reclamation, Corps of Engineers, and the Environmental Protection Agency should be continued and accelerated. State water right laws should be revised where necessary to encourage and facilitate water conservation and reuse by agriculture, municipalities, and industry. Local water districts should give more attention to maximizing output per unit of water input. Application of water pricing measures, where practical, would make it economically desirable to curtail the inefficient uses of water.

An overall effort at Federal, State, and local levels is necessary to take full advantage of means now available to increase or stretch water supplies through conservation and reuse.

Water From Weather Modification.—Since the beginning of time man has attempted to influence the weather—by prayer, by ritual, by a large number of gadgets and innovations, and finally through scientific research. At last man is on the threshhold of realizing this age-old dream.

As a result of a great deal of public and private research and study, and particularly of the intensive 13-year research program of the Bureau of Reclamation, precipitation management technology is now sufficiently developed to warrant demonstration programs of winter cloud seeding in mountainous areas looking to application of full-scale operations in water-short areas of the Nation. The importance of this potential to the water-short and potentially water-short regions of the West is obvious.

That portion of the United States from the Rocky Mountains west to the Pacific Coast receives much of its annual precipitation during the winter. Essentially all of the rivers headwater in the mountains and derive their water from snowmelt. If the clouds that form over the mountains can be made to precipitate more of their water in passing, the water supplies of the West would be improved significantly. In general, the goal of such orographic cloud seeding is to keep the annual snowpack in years of below normal snowfall close to the historic long-term average.

Comprehensive field experiments have provided most of the development and testing of techniques in different areas under different cloud conditions. Winter orographic experiments have been carried on in seven States. Experiments during the 1973-74 winter season were conducted in Colorado, Utah, California, and Nevada. Summer cumulus cloud seeding experiments have also been carried out in seven States over the past 12 years. Current plans are for an extensive High Plains experiment on the modification of cumulus clouds over the next 5 to 7 years.

Today's technology is reasonably good at recognizing whether a seedable situation exists. The technology is not as good at telling how much precipitation will fall from a particular cloud system if it is seeded and if it is not seeded. Several techniques can be used to make such a determination, but mathematical models are probably the best tools currently available for the job.

Potential of winter orographic cloud seeding for increasing the water supply in the 11 Western States has been investigated for 12 mountain areas and the related river basins — the Upper Colorado, Rio Grande, Truckee-Walker-Humboldt, Sacramento, San Joaquin, North Platte, Upper Missouri, Bear-Wasatch, Gila, Snake, Deschutes, and Yakima Basins. For these 12 areas, which do not cover the entire potential of the West, it is estimated that average annual water supplies could be increased from 7.5 to 10 million acre-feet by weather modification. While this represents only a 2 to 3 percent increase in water yield for the 11 Western States, it becomes a 4 to 5 percent increase for the area outside of the Columbia-North Pacific Region. For the Upper Colorado River Basin the potential increase in annual water yield could be from 6 to 9 percent and for the Upper Rio Grande from 8 to 11 percent. For these two water-short basins, weather modification could make a major contribution in meeting future water demands.

One of the most attractive aspects of weather modification is the projected low cost. Present estimates indicate a total cost of about $2.50 per acre-foot of high-quality water ($1.50 for seeding operations and $1.00 for environmental protection and contingencies).

While solution of the technical problem of weather modification is well advanced, many of the problems related to the social, legal, and environmental implications of cloud seeding are still to be resolved. Experience while developing precipitation management technology has taught that most sociological problems can be resolved when an effective education program is coupled with an honest attempt to involve local people in the planning and decisionmaking phases. For this reason, most precipitation management projects are preceded by months of public discussion. Local officials and interested citizens are involved as much as possible. After the seeding project is

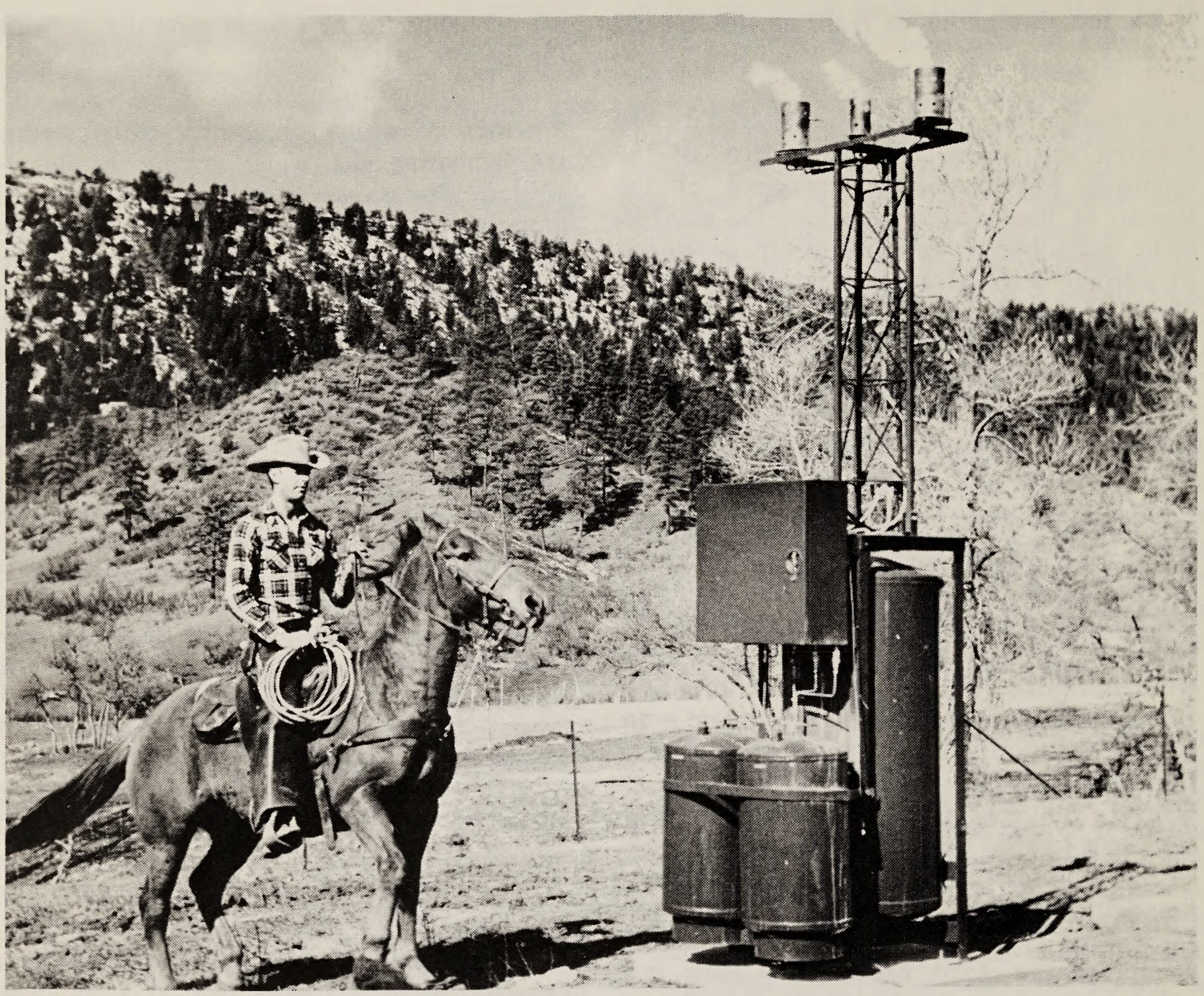


Figure 7. Silver iodide generator in San Juan Mountains, Colorado.

under way, periodic progress reports are issued to the public.

The legal aspects of precipitation management are very complex at the present time. Some states have specific laws to regulate weather modification (one state prohibits it altogether), others simply require the reporting of activity, still others have no laws whatsoever. There is little in the way of judicial precedent to use as a guide. The question of liability has not been resolved and companies which insure cloud seeders have little or no experience with cloud seeding claims upon which to base their rates.

Precipitation management, successfully carried out on a large scale for an extended period, will almost certainly have an effect on the environment. It will tend to stabilize the precipitation – that is, dry years will not be so dry. Such a program would favor plants and animals adapted to a wetter environment with less variation from year to year.

Results of studies to date suggest no large effects on plant and animal communities from the changes in precipitation expected. No adverse effects of silver iodide have been determined. Ecologists are developing models that will be able to predict with a fair degree of accuracy the effects of prolonged precipitation modification. There is no evidence that precipitation management creates irreversible effects on any natural system. More study and research, however, are required.

Because of the potential importance of weather modification as an extremely low-cost source of new water supply for water-short areas in the West, weather modification programs should have high priority support. Emphasis should be given to resolving the remaining problems arising from sociological, legal, and environmental considerations. A substantial demonstration program of several years duration, preferably in the Upper Colorado River Basin, should be initiated as soon as practicable to verify and better quantify the findings available to date.

Water Pollution and Urban Waste Water Management. – In the public mind the pollution of our rivers generally is associated with their degradation from large volumes of untreated or inadequately treated municipal and industrial wastes. In the East this commonly is the case. In the West, however, with its vast open spaces interrupted only occasionally by metropolitan centers, it is only near such centers that municipal and industrial wastes are major contributing factors to water pollution. Further, a great portion of the West's population resides on the West Coast where municipal and industrial wastes are discharged into the ocean and thus do not contribute to pollution of western streams. For the great bulk of western rivers, the major sources of pollution stem from natural sources and from agricultural pursuits.

Sediment from erosion containing natural salts and minerals constitutes the greatest volume of any pollutant in the surface waters of the West. Other pollutants such as plant nutrients, pesticides, and heavy metals are also carried by sediment. Erosion of crop lands, drainage channels, unprotected forest lands, overgrazed lands, strip-mined areas, roads, and other construction areas contribute to the total

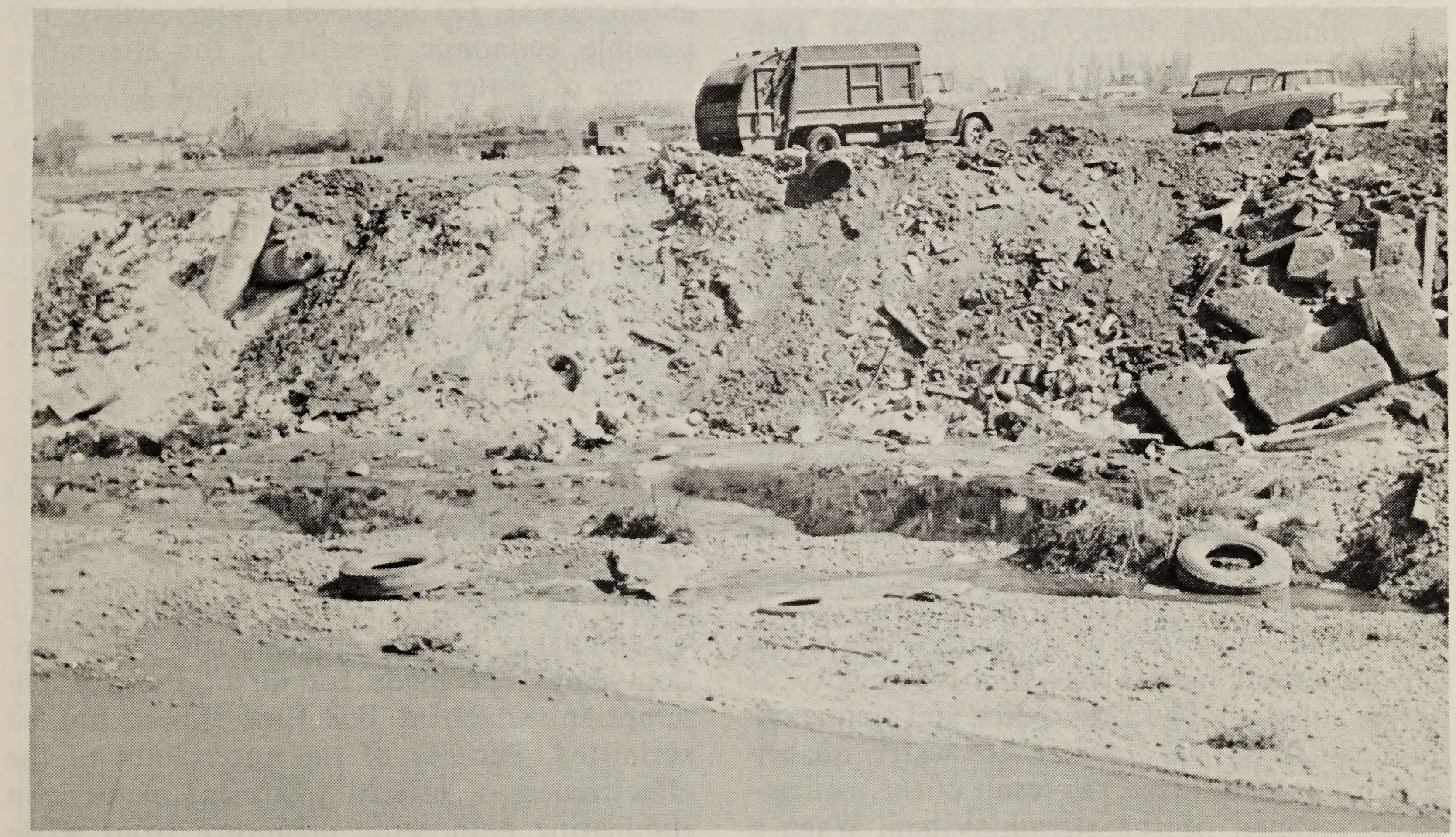


Figure 8. Pollution of South Platte River from city dump.

sediment load. Sediment originating from these sources is a serious problem in many areas throughout the Western States. Erosion problems occur on both irrigated and nonirrigated lands. Sediment decreases the storage capacity of reservoirs, increases treatment costs for domestic and industrial water supplies, damages fish life, and reduces recreational and aesthetic values. Existing erosion control technology has not been universally used, primarily because of direct or indirect economic considerations.

Fertilizer usage has expanded rapidly in the West in recent years, not only in agriculture but in other uses such as for forest lands and recreational areas. This usage has raised many questions concerning nutrient pollution of surface and ground waters. The objective of maximizing crop production is not always compatible with the objective of reducing nutrient pollution of water. Proper use and management of fertilizers will need more study.

In recent years, there has been a tremendous increase in pesticide usage on both irrigated and nonirrigated lands. In some areas high levels of certain pesticides have killed fish and other aquatic life and populations of many aquatic and predatory birds have been reduced as a result of feeding on affected aquatic life. Pesticides must be used wisely to avoid water pollution and other environmental problems that may affect human health and welfare.

Irrigation is an important cause of water quality deterioration in many streams of the West. It not only increases the salt loads in streams but, as the major consumptive user of water, it reduces the capacity of streams to dilute the natural salt loads.

The nature and extent of streamflow regulation are important factors affecting the quality of water supplies. The occurrence and frequency of low flows are critical to water quality control and are often the result of the management regimen of the stream system. When a free-flowing stream is impounded, its physical, chemical, and biological characteristics are modified, thereby resulting in changes which can be either beneficial or detrimental to water quality.

As the water resources of the West become more completely utilized, the ability of stream systems to assimilate the used waters and their wastes may be just as important as providing adequate amounts of water for various uses.

Control of pollution from municipal, industrial and agricultural sources is being advanced in all Westwide areas under a joint State-Federal program as established by the Federal Water Pollution Control Act Amendments of 1972. An important part of this program is the activity related to urban waste water management. The objectives of waste water management are not only to treat municipal and industrial wastes to meet waste discharge requirements but also to promote further use of treated waters and the byproducts of treatment such as sludge.

Some benefits which can be obtained from waste water management are: (1) additional use through recycling, (2) environmental enhancement, (3) improved water quality, (4) possible economic benefits if the alternative source of water is expensive, and (5) many intangible benefits.

Some of the factors which govern the use of reclaimed water are: (1) quantity; (2) quality, including health standards, (3) legal rights, (4) economics, (5) public acceptance of reclaimed water, (6) environmental consequences of discharging wastes, and (7) discharge standards.

Recycled waste water can be put to many uses. Irrigation of crops, development of recreational areas, and cooling water are the more common. Restrictions on the use of recycled water should be based on the acceptibility of the water quality for the intended use. An exception should be made for direct human consumption, which at this time should not be permitted. Because of the uncertainty of the effectiveness of present treatment methods in eliminating pathogenic organisms from waste waters and the inability to identify and propagate them in the laboratory, and because of the uncertainties of the long-term effects of stable organics, there is a general feeling at this time that waste water should not be directly reused for drinking purposes. Further research is needed in this area to be sure that public health is not endangered.

The responsibility for waste water management rests with the states and local interests. They may request Federal agencies to assist them in meeting the goals of the 1972 act. Under its Urban Studies Program, the Corps of Engineers has 6 urban studies underway in the 11 Western States: Seattle-Puget Sound, Spokane, Boise, Denver, San Francisco Bay and Sacramento-San Joaquin Delta, and Salinas-Monterey. The Bureau of Reclamation is engaged in a study of Las Vegas Wash pollution in Nevada and a countywide study for Ventura County, California.

Because of the many potential benefits of urban waste water management, this approach to treatment of municipal and industrial wastes should be encouraged particularly in the water-short and potential water-short areas of the West.

Increasing Salinity in Major River Systems. – Mineral pollution of surface waters, commonly known as salinity, is a problem that is becoming increasingly serious throughout the Western United States. The problem results from both natural and man-related actions.

The two basic causes of rising salinity levels in streams of the West are the salt-loading and the salt-concentrating process. Salt loading results from the absorption of additional mineral salts into the streams from such sources as natural inflows, irrigation return flows, and municipal and industrial wastes. In contrast, the salt concentrating effect occurs as a result of the consumptive use of water where the salt tonnage remains in the stream but where there is less water left in the stream to dilute the salt concentration.

In arid and semiarid regions the soils generally contain larger amounts of salts than in humid regions and the surface waters generally have higher salt concentrations. Man-related activities are the basic cause, however, for the increase in salt concentration of western streams over and above those of natural conditions.

Irrigation is the major contributor to increasing salinity. Irrigation consumes large amounts of water leaving less water in the stream systems to dilute natural salts. Growing plants also, in addition to consuming water, leave salt behind resulting in a concentration of dissolved mineral salts already present. Irrigation return flows provide the vehicle for conveying the concentrated salts to a receiving stream.

In most regions of the West, the detrimental effects of salinity are confined to consumptive uses of water. The existing levels of salinity in most streams appear to have relatively little detrimental effect on nonconsumptive instream uses such as for fish and wildlife, recreation, navigation and hydroelectric power generation, but this aspect needs more research.

Within the Westwide area the streams most adversely affected by increasing salinity are in the lower river reaches of the Southwest. These include the Colorado River, the Rio Grande and Pecos Rivers in New Mexico, the San Joaquin River in California, the Sevier River in Utah, the South Platte and Arkansas Rivers in Colorado, and other smaller streams.

Detrimental effects from excessive salinity in water supplies are primarily economic in nature and include such effects as reduced crop yields, loss of productive land base, increased water requirements for irrigation, higher management and operating costs, added treatment costs for municipal supplies, corrosion and scaling of pipes and equipment, accelerated fabric wear, and others. In addition, these losses in production or reduced economic activity result in less employment and personal income in other activities such as marketing, processing, and transportation.

It appears that the most practical means of reducing salt loads and thus halting or reversing the trend toward increased salinity include impoundment and evaporation of point source discharge, diversion of runoff and streams

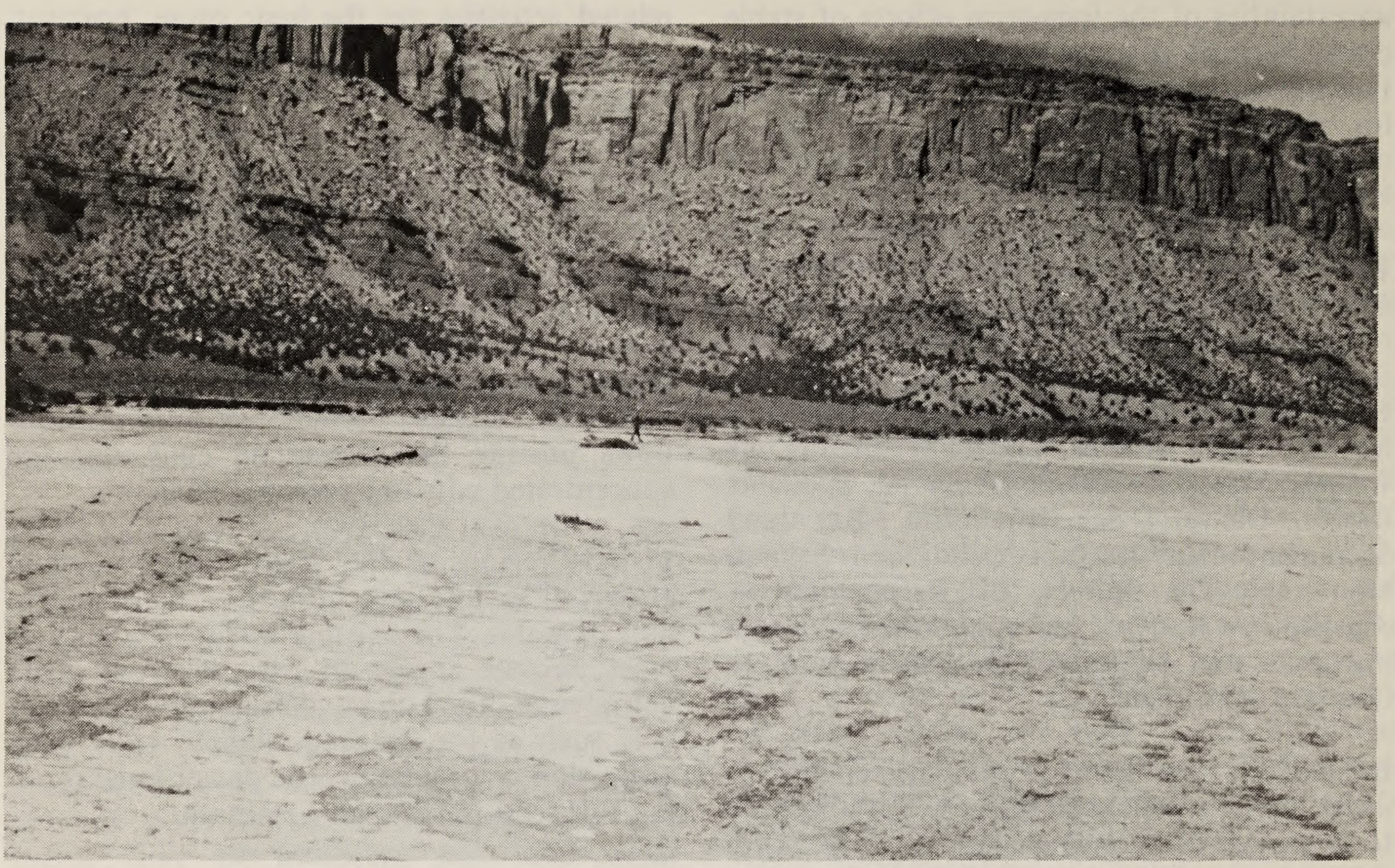


Figure 9. Salt crustations on riverbed of Dolores River, Paradox Valley, Colorado.

around areas of salt pickup, improvement of irrigation conveyance facilities, improvement in onfarm irrigation systems and water management, improved management and treatment of land contributing salts from natural diffuse sources, retirement of high salinity contributing irrigated lands, and desalting of saline discharges from natural and manmade sources. It may be possible for some of these measures to be implemented in a variety of locations and combinations to achieve basinwide management and control of salinity.

A number of Federal agencies, including the Environmental Protection Agency, Bureau of Reclamation, Department of Agriculture, and the Geological Survey, have ongoing research and other studies which will contribute to the development of control technology for pollutants associated with irrigated agriculture. Several of the Western States also are increasing their efforts to develop more effective control measures and techniques for agricultural pollutants.

Control of salinity levels should be an important part of all water supply planning studies. Ongoing research aimed at finding practical and economical methods of controlling pesticides, fertilizers and minerals in irrigation return flows should be pursued vigorously.

Erosion and Sedimentation. – Erosion and sedimentation from both natural and manmade causes occur extensively throughout the West. Erosion at greater than 0.5 acre-feet of soil per square mile per year, the point at which serious problem erosion begins, occurs on 155,000 square miles or almost 15 percent of the area of the 11 Western States. More moderate erosion, from 0.2 to 0.5 acre-feet is found on an additional 330,000 square miles. Another aspect of the problem is that serious erosion is found on 46,000 miles and moderate erosion along 185,000 miles of stream channels in the West. The average annual rate of erosion for the Rio Grande basin in New Mexico is 0.59 acre-feet per square mile while the average rate for the entire Colorado River basin is 0.44.

Erosion is affecting the public and private land resource base through excessive agricultural soil losses resulting in lower productivity, higher production costs, and social costs. Sediment, the product of erosion, causes damage in streams, rivers, lakes, and wherever it is deposited. It accumulates in reservoirs, increases treatment costs of municipal and industrial water supplies, clogs navigable streams and irrigation and drainage improvements, smothers growing plants and harvestable crops, increases maintenance costs of utility and transportation facilities, decreases the recreational value of water, and adversely affects the fishing resource.

The erosion-sedimentation process also is a major contributor to salt loading in western streams.

Sedimentation and erosion problems occur in range, grassland, forest, cropland, and urban areas in some form in all of the Western States, but they are greatly accelerated where man's activity has modified the vegetative cover.

Ongoing Federal programs have been dealing with soil erosion and sedimentation problems for years. These include technical, cost-sharing and credit assistance programs of the Department of Agriculture for privately owned lands. These programs are being carried out cooperatively with State and local organizations such as conservation districts and through the efforts of the landowners and operators. The Bureau of Indian Affairs provides similar assistance for tribal lands. Erosion and sedimentation control measures have been a part of multiple-purpose water and related land resource projects of the Corps of Engineers, Bureau of Reclamation, and the Soil Conservation Service. Land managing agencies such as the Forest Service and Bureau of Land Management have soil erosion control programs. In recent legislation the Corps of Engineers has been authorized to carry out erosion control programs for streambank and coastal areas. These programs adequately applied can minimize erosion and sediment damage. However, greater emphasis needs to be placed on the water quality aspects of these problems.

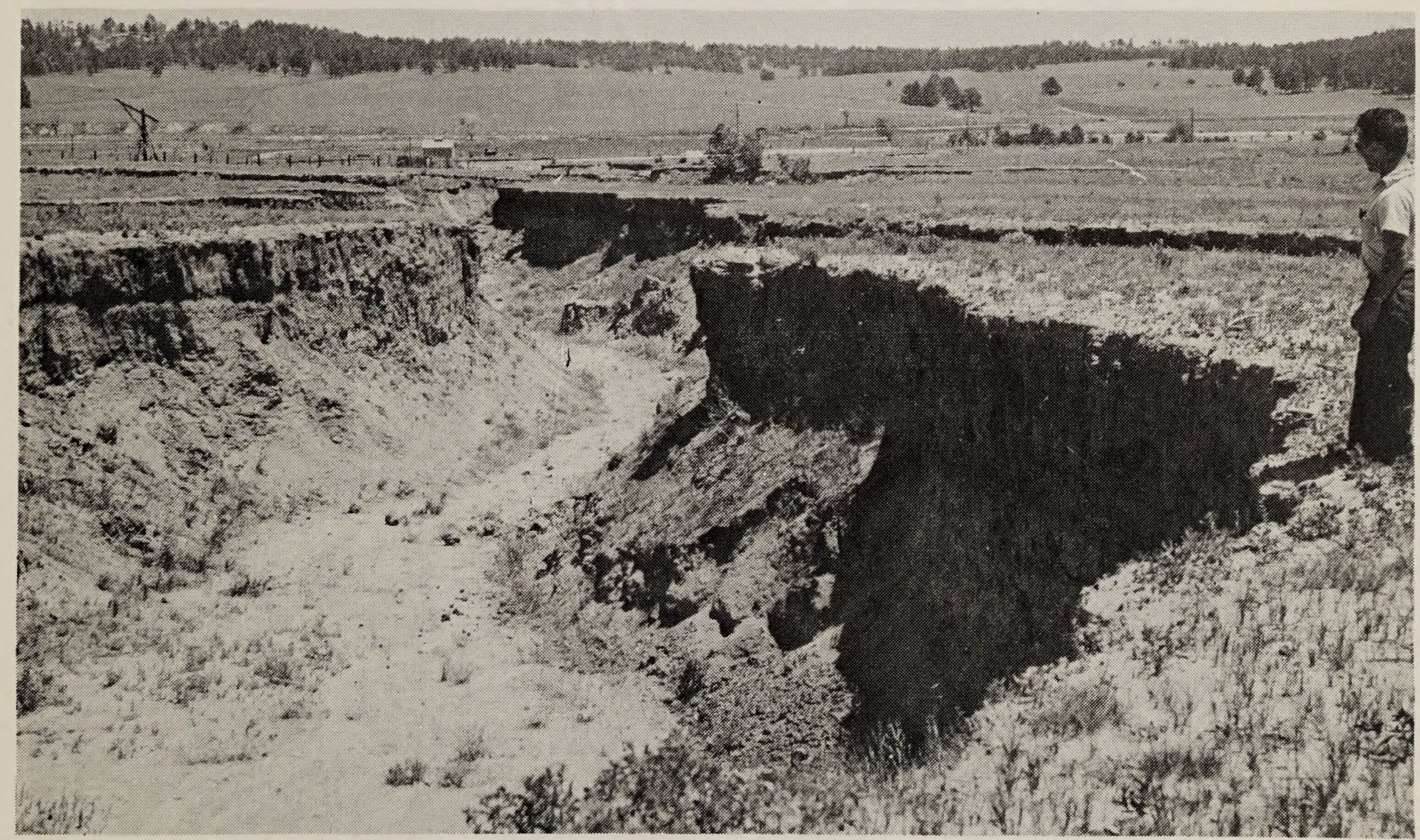


Figure 10. Typical stream erosion on Western lands.

control programs under the Federal Water Pollution Control Act and related State programs will give consideration to these water quality aspects.

The Environmental Data Gap. – The growing national concern of recent years over the protection and preservation of environmental values is not matched in many specific areas of concern by the ability of environmental experts to analyze and predict accurately the consequences of water resources development. In large part, if not totally, this is due to lack of necessary basic data.

Since the turn of the century the major emphasis in water resource matters has been on water resources development. As a result a vast storehouse of data has been accumulated that permits the water resource planner to determine the exact quantity and quality of water required for a successful irrigation development, or to determine accurately the effects of various water qualities on municipal and industrial activities, or to determine the combination of range and irrigated land to sustain a cattle operation, or to determine the exact water needs of a hydroelectric power operation. Comparable data are not available to the fishery biologist to determine instream flow requirements for fisheries or for freshwater inflow requirements into estuarine waters. Nor are there comparable data available to the wildlife biologist to determine the exact winter browse availability and requirements of big game.

The major areas of environmental data deficiencies are related to (1) instream requirements, both quantity and quality, (2) riparian and wetland areas, (3) threatened and endangered species, (4) coastal ecosystems, (5)

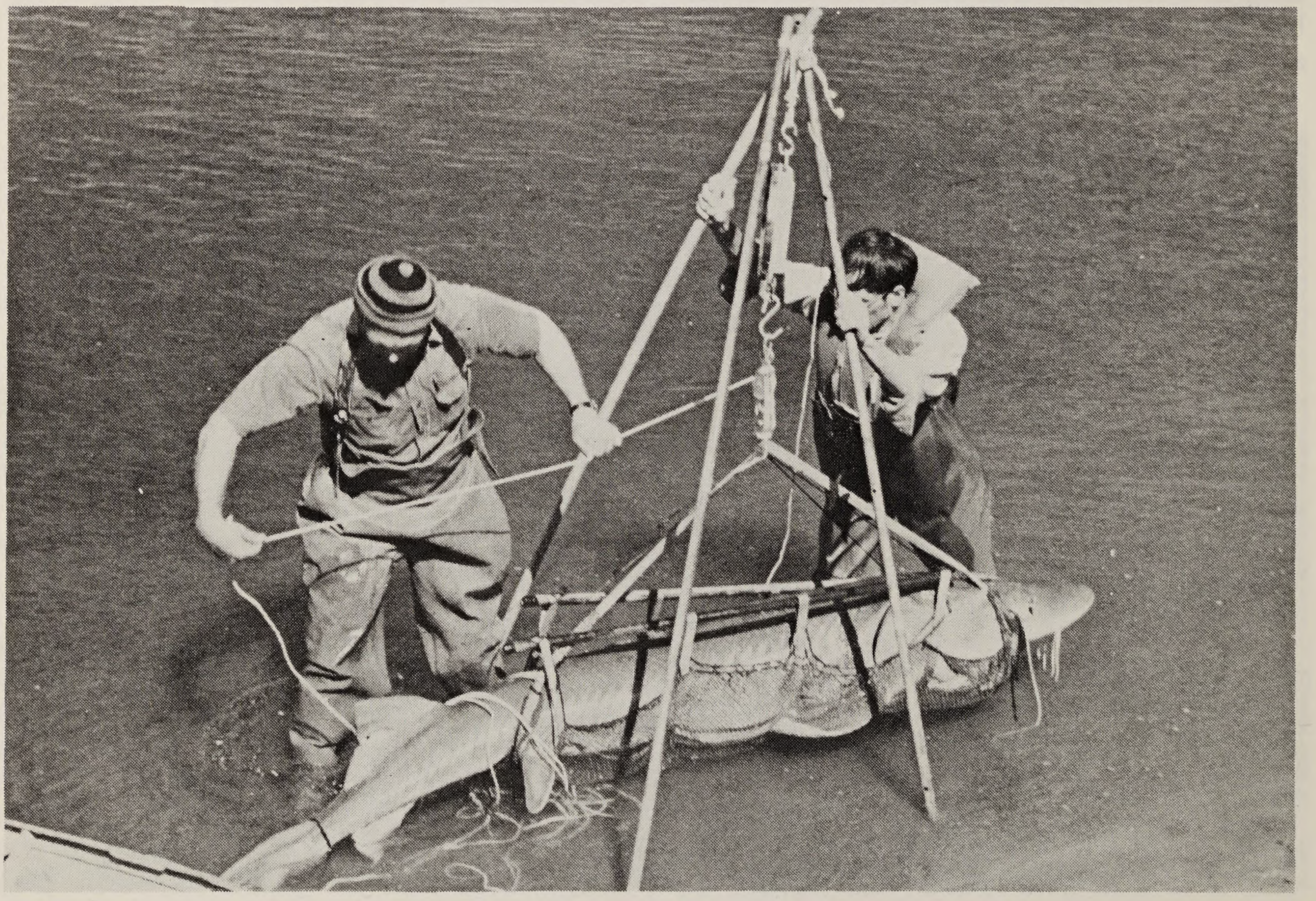


Figure 11. Weighing and measuring a giant sturgeon captured in the Hells Canyon stretch of the Snake River.

critical big game winter range, (6) recreation area protection needs, carrying capacities, and reactions to impacts such as extensive development of energy resources, and (7) potential nationally significant natural areas.

Free-flowing streams provide opportunities for unique cultural, scientific, and recreational activities that are in short supply in many areas. Water development projects often modify stream conditions and alter their capacity for fish production, recreation, and maintenance of desirable natural conditions. Determinations of specific instream flow needs in the past have often been accomplished under the pressure of short study deadlines and without the availability of adequate basic data. Determination of instream water needs for all of those streams in the West with significant environmental values is a long-term task. It is important that such studies be completed as early as possible.

A difficult aspect of instream requirements is that for the most part water laws of the Western States are based on the law of appropriation and provisions guaranteeing minimum or adequate sustained streamflows are weak or lacking. Recent changes in State legislation in some states, including Montana, Colorado, Washington, and Oregon are intended to recognize instream flows for recreation, fish and wildlife, and aesthetics as beneficial uses. Legislation is needed in other Westwide States to protect suitable base flows in perennial streams.

Wetlands are among the most important types of habitat for wildlife in the West. They are also among the most vulnerable to change. Waterfowl, shore birds, marsh birds, and fur bearers by the million use wetlands to raise their young, as critical resting and feeding areas during migration and as year-round habitat. While earlier inventories, mostly in the early 1950's, showed extensive past losses to wetlands, no recent surveys have been undertaken to determine the current status of such areas. It is important that new surveys be made to know which areas have remained unchanged as well as what has been gained or lost, what has deteriorated significantly, what is most vulnerable to early damage, and what areas could be restored by provision of adequate water supplies.

One of the unfortunate consequences of growth and development in the West has been the extermination of some native species of fish and wildlife and the threat of extinction to other species. The Endangered Species Conservation Act charges the Secretaries of the Interior, Agriculture, and Defense together with the heads of agencies within their departments with the protection of species of native fish and wildlife, including migratory birds, that are threatened with extinction, and, insofar as is practicable and consistent with the primary purposes of such agencies, with the preservation of the habitat of such threatened species on lands under their jurisdiction.

In the 11 Western States area, endangered species of immediate concern include the humpback chub, the Colorado River squawfish and the woundfin in the Colorado River basin; several trouts – the Apache trout in the White River, the Gila trout in the Gila River, the Paiute trout in Alpine and Inyo Counties, California, the Greenback cutthroat trout in the Cache La Poudre drainage, and the Lahontan cutthroat trout of Pyramid Lake; the Devils Hole pupfish and the Pahrump killifish in the Great Basin; the Yuma clapper rail and Mexican duck along the Lower Colorado River; the Kendall warm springs dace in Wyoming; the Southern bald eagle in the Southwest; the Northern Rocky Mountain wolf, Idaho; and the American peregrine falcon in Idaho, Wyoming, Nevada and Utah.

For all the above endangered species and for a much larger number of threatened species the specific habitat and other requirements necessary for their survival are not known in nearly enough detail to permit adequate consideration in water resource planning activities. There is critical need for a greatly stepped-up research program so that these species are not "guessed" into extinction as water control facilities are provided.

Coastal ecosystems include tidal wetlands and estuaries. These fragile systems are of special significance in the Westwide area because they provide outstanding recreation opportunities and basic life support for much of the Pacific Coast fishery resources and at the same time serve as important nesting, resting, and feeding habitat for a variety of birds, fur bearers and sea mammals. Coastal areas have been altered by man at a rapid rate through dredging, filling, channelization, pollution, and diversion of freshwater inflows. Natural functions of many ecosystems will be significantly degraded or essentially lost in the near future without proper planning and management.

The primary emphasis of the Westwide Study was limited to the freshwater inflow aspects of the estuaries. The most critical related problem in preparing multiple-purpose water development plans is the lack of basic biological information. Studies to obtain such biological information should be initiated immediately concentrating on estuaries where development pressures are most evident or where natural areas appear most vulnerable.

Big game winter range has been degraded and extensively reduced by farm, industrial, recreational, and other developments. Major contributors to critical habitat losses have been water use and control projects. Severe wintertime reductions in big game herds in recent years signal the need for a major effort to increase winter range productivity. Conventional approaches of compensating for winter range losses include revegetation and control of livestock grazing on remaining winter range. The extent of such compensation is meager compared with the possibilities inherent in irrigation of native and exotic woody plants that provide big game browse. A long-term research program is needed to ascertain potentials in irrigated browse management.

Environmental data deficiencies related to outdoor recreation cross a broad spectrum of natural resource and social concerns. Data generally are lacking on the quality and quantity of recreation opportunities that are associated with various riverflows and the possible conflicts that recreation riverflows may have with other uses. At present very little information is available on carrying capacities and protection and management of various recreation resource types, especially those involving fragile ecosystems such as are associated with high mountain lakes and streams. More needs to be known about the consequences of the loss of open space and recreation resources to urbanization. More also needs to be known about the handling of recreation resources in flood plain management and about the long-range impact of energy resource development on recreation resources.

A joint State-Federal effort is required to assure that necessary basic environmental data are collected, presented, analyzed, and used in decisionmaking. First priority for implementing studies is focused in those areas of Colorado, Wyoming, Utah, Montana, and New Mexico where large scale development of energy producing resources appears imminent.

Wild, Scenic, and Recreational Rivers. – The Wild and Scenic Rivers Act of 1968 declares it to be the policy of the United States that "* * * certain selected rivers of the Nation which, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, shall be preserved in free-flowing condition and that they and their immediate environments shall be protected for the benefit and enjoyment of future generations."

The act established a Wild and Scenic River System by designating eight rivers as immediate components of which five are in the Westwide area. These are stretches of the Rio Grande, Feather, Rogue, Salmon, and Clearwater Rivers. Additional rivers can be added to the system by (1) Federal legislation or (2) State legislation and approval of the Secretary of the Interior. The act also designated 27 other rivers for detailed study, of which 10 are in the 11 Western States, and sets forth a mechanism by which the Secretaries of the Interior and Agriculture may recommend that Congress add new rivers to the 27 already under study.

Figure 12. North Fork of Gunnison River, Colorado.

During the early stages of the Westwide Study, lists were compiled of rivers and streams that had been recommended in proposed legislation or in official reports and correspondence as suitable for preservation. The totals for the 11 Western States revealed that over 500 stream reaches aggregating more than 20,000 miles have been so identified. Virtually every major and most minor rivers in the West, at one time or another, have been identified by various interests as having free-flowing values worthy of preservation. The Westwide State Study Teams identified 77 river stretches to be studied as potential additions to the Wild and Scenic River System. These 77 rivers include a number of streams identified by the Secretaries of Interior and Agriculture in 1970 as potential additions to the National System which must be, pursuant to the Wild and Scenic Rivers Act, "evaluated (for their Wild and Scenic river potential) as part of any Federal planning involving the use of water and related land resources in the river areas."

It is obvious that not all proposed rivers can or should qualify as critical problems requiring immediate study. The Westwide Study has identified 22 instances of immediate concern involving potential conflicts in use. Studies of these river reaches should be undertaken as soon as possible. Sixteen of these 22 rivers are included in proposed new Federal legislation supported by the Secretary of the Interior to study potential additions to the National Wild and Scenic Rivers System.

Proper implementation of not only the Wild and Scenic River Act but also the National Environmental Policy Act and the approved Principles and Standards for Water and Related

Land Planning should provide a needed planning basis for addressing and resolving conflicts between development and preservation.

Finally there is a growing interest in many states to establish State wild and/or recreational river systems. In many instances this may be a viable alternative for determining how certain rivers should be developed and managed. States could use zoning or less-than-fee acquisition methods in achieving scenic river preservations. States and local governments could limit or prohibit the placement of structures; designate location of structures in relation to a river's edge, property or subdivision line, and floodflows; limit the subdivision of lands and control the location and design of highways, roads, and public utility transmission lines; and prohibit or limit the cutting of trees or other vegetation within specified distances from a river's edge. Such measures would add further to the protection of valuable river resources.

Wilderness Areas. – The Wilderness Act of 1964 established a National Wilderness Preservation System for which about 11 million acres has been designated. Most of this acreage is in the Westwide area and not only is of special value to this region, but also represents a nationwide wilderness resource base.

Many potential additions to the system are being considered. These include tracts within the National Forests, the National Wildlife Refuge System and the National Park System. Lands administered by the Bureau of Land Management are not covered by the Wilderness Act but legislation is being considered to extend provisions of the Act to these lands.

Land and water uses and activities incompatible with wilderness objectives and not well established on a prior basis are precluded or restricted with the establishment of a wilderness area. The collection, storage, and conveyance of water supplies are not permitted

Figure 13. High Uintas Primitive Area, Utah.

nor are physical structures such as stream gaging stations or snow fences to increase runoff permitted. Such restrictions apply also to areas designated as potential wilderness study areas. It is important, therefore, in areas where there are potential conflicts between wilderness values and water development and weather modification objectives, that studies necessary to final decisions be made promptly.

Flat Water Recreation. – The spectacular growth in outdoor recreation activity over the past 15 years shows no signs of abating. Water-dependent activities such as boating, swimming, fishing, and water skiing account for one-fourth of present outdoor recreation use.

One of the initial appraisals of the Westwide Study was the analysis of information obtained from Federal interagency comprehensive river basin studies and from State recreation plans on water-based outdoor recreation needs. Areas of critical need were identified, the major ones including the populous South Pacific Coast area from San Francisco to San Diego; the Front Range of the Rocky Mountains north and south of Denver; the Phoenix-Tucson area; and the Rio Grande Valley in the general vicinity of Albuquerque.

The prospect for new reservoir projects becoming useful recreation resources before 1985 is extremely limited, except for the Auburn and New Melones Reservoirs in California and possibly for the Phoenix-Tucson area where the Central Arizona project is now under construction. An alternative for meeting these critical needs is to increase the effectiveness of existing streams, lakes, and reservoirs.

There are 679 major reservoirs in the 11 Western States many of which are playing an important role in meeting recreation needs. Many others have unrealized potentials. Most

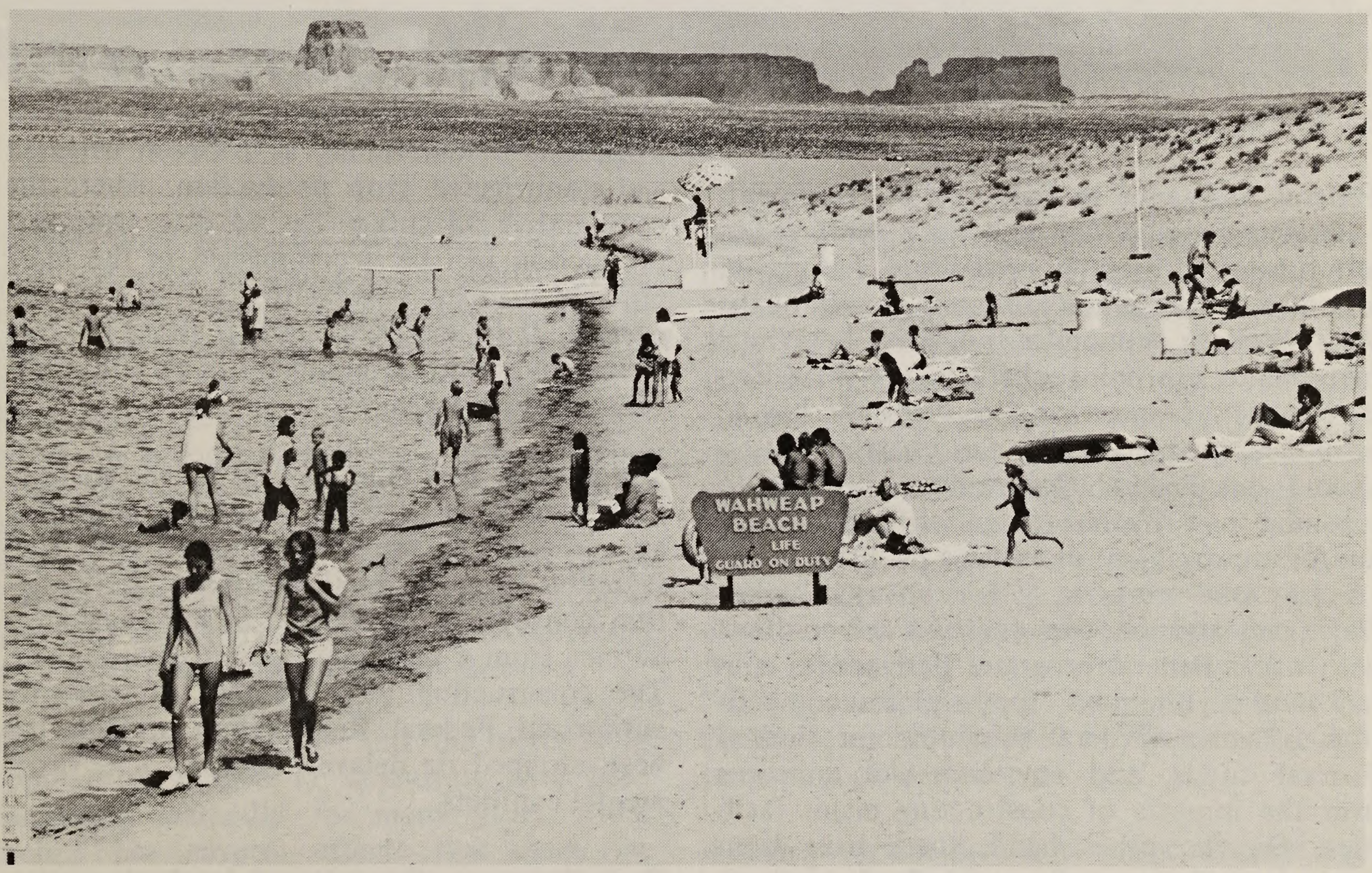


Figure 14. Swimming beach at Lake Powell, Arizona-Utah.

of the existing Federal reservoir projects were planned, authorized, and constructed many years ago prior to the time that outdoor recreation was treated as a bona fide project purpose. Originally built primarily for such purposes as irrigation, power, and flood control, some of them may have become more valuable for recreation than for the original purposes. Yet, they continue to operate with grossly inadequate recreation facilities and in a manner that precludes realization of their great recreation potential.

Based on information developed by the Westwide State Study Teams, there are more than 100 Federal reservoirs which have high untapped potential for meeting recreation needs. Twenty-three of these reservoirs have been selected in the Westwide Study for priority consideration and study. Multiagency studies of these reservoirs should be conducted as soon as possible to determine if greater economic and social benefits could be realized by reallocations of stored waters, modification of operations, and provisions of additional recreation facilities. Study of the remaining reservoirs should follow. Comparable studies of non-Federal reservoirs should also be made by the proper entities.

Federal Assistance to Irrigation Development. – Irrigated agriculture, and since 1902 federally subsidized irrigated agriculture, has played a dominant role in the economic growth of the West. Western economics, however, have now matured to the point where further irrigation development is questioned as being the key to economic growth. Thus, the question arises, should the Federal Government continue to subsidize new Western irrigation development and/or improvement of existing facilities.

Impinging also on this question are conflicts with other Federal programs designed to control food supplies and crop surpluses, competition of other Federal programs for limited Federal funds, and environmental concerns over the impacts of constructing major facilities. On the other hand, there have been marked depletions of world food reserves, greater recognition of the economic and political advantages of producing abundant supplies to maintain a favorable balance in international trade and to promote world peace, and increased interest in rural development and population distributions.

The whole future of the Federal irrigation program should be assessed in light of the unexpected changes in American agriculture which have led to dramatic effects on national agricultural policy. Increased export trading has virtually eliminated excesses of U.S. agricultural supplies. Quantities of some commodities are such that prices have more than doubled, and export embargoes have been enacted to protect domestic markets. Within a very short time frame, agricultural policy has changed from one of restricted production to one of encouraging increased production. The thrust of the recent policy is to assure consumers of plentiful food supplies, expand and firm up the export market to give a much needed assist to our balance of payments, and stabilize farm income without dependence upon government price-support programs.

In the face of this current policy of stimulating food and fiber production, it is important, in appraising the future role of federally assisted irrigation, to determine, as between irrigated and nonirrigated crop production, where the comparative advantage lies so that additional production can be accomplished in the most efficient manner. This factor is not now clearly evident. It is important also to assess the role of the continuing development of private irrigation and its relative cost.

The increase in public concern for the environment evidenced in recent years has generated an awareness of impacts associated with construction of major dams, reservoirs, and irrigation conveyance works that in some instances detract from a desirable natural environment. The construction of a number of presently authorized Federal Reclamation projects has been stopped or delayed because of environmental conflicts.

Over the years, the costs of developing irrigation projects increased because more complex

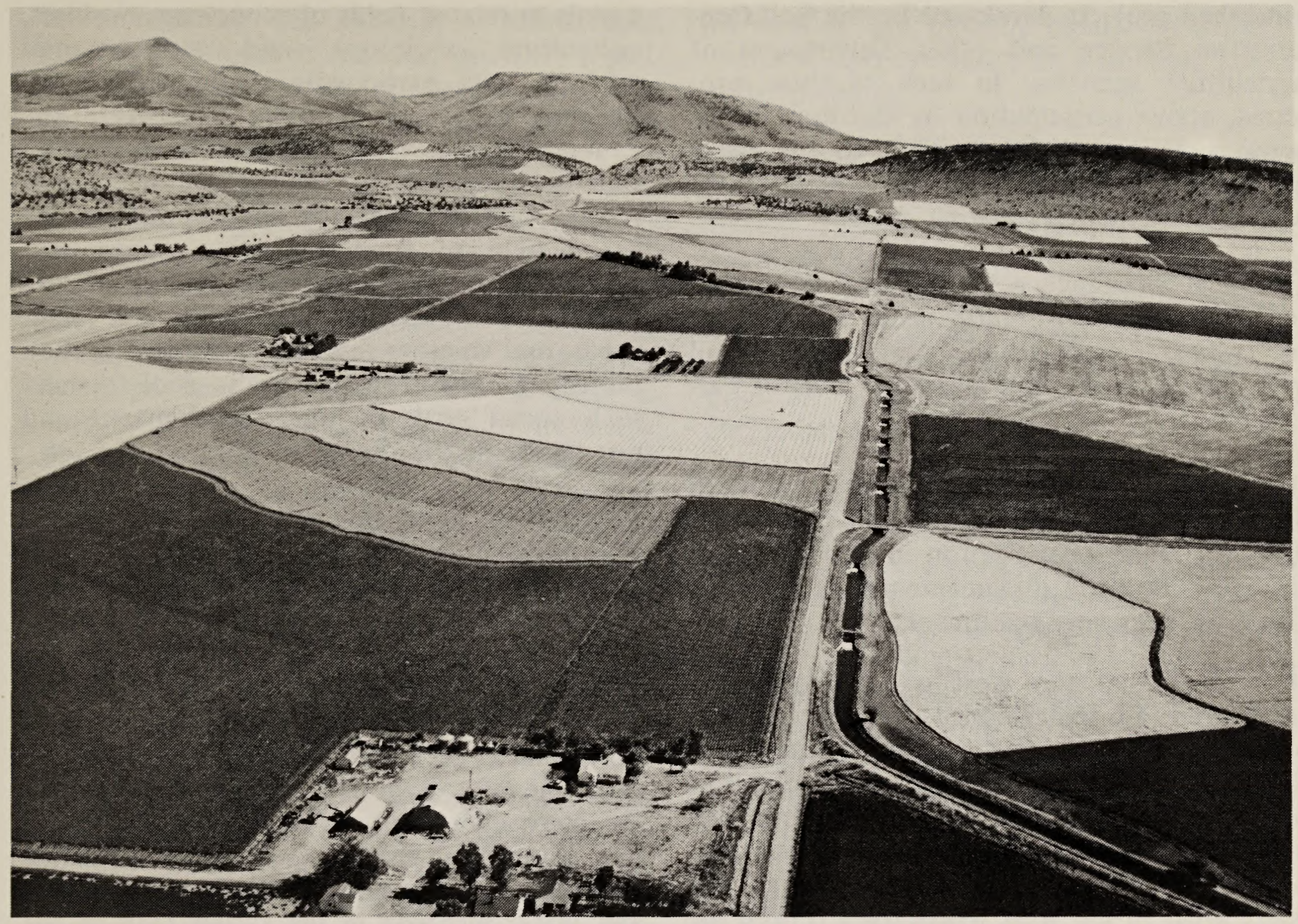


Figure 15. Irrigated lands, Deschutes project, Oregon.

systems were necessary to develop remaining land and water resources. Concurrently, prices and values for agricultural products tended to remain static, resulting in a marked increase in subsidies for Federal irrigation development. With ample supplies of food at reasonable prices on supermarket shelves, other pressing economic and social demands for Federal funds captured the attention of the public and of Government officials. Greater emphasis in Federal irrigation development may occur if food shortages persist and cannot be corrected with other lower cost short-term measures.

The number of people and the percent of population engaged in agriculture have been decreasing markedly for many years. Rural decline has adverse effects that reach far beyond the originating farm areas. Migration from the farm has compounded urban problems associated with overcrowding, inadequate housing, unemployment, increasing crime, pollution, and general environmental deterioration. These social problems of urban concentration are recognized to be of major national concern. Programs which serve to build up sparsely settled areas and disperse population can have a beneficial effect in lessening the impacts of further rural decline.

Several federally funded programs have played a part in the development of irrigation in the West. These may be roughly categorized as "action" programs and "technical assistance" activities, each designated to meet a particular pressing goal or need.

Action programs include the major storage and irrigation distribution works constructed by the Bureau of Reclamation and the small watershed projects developed by the Soil Conservation Service and other Department of Agriculture agencies. In each of these programs, active participation by the local water users is an essential ingredient to successful planning and operation of the project. Such participation includes sharing of costs.

Technical assistance activities are very broad, covering numerous onfarm needs with respect to water management, erosion control measures research, and education aids of various kinds.

It is difficult to measure the impact that each of these federally assisted programs and activities has made on irrigation in the West, but there can be little disagreement that the total effect has been very significant.

It is clear that the West can no longer be considered an undeveloped area. Settlement policies and other aspects of the Reclamation program are changing direction and emphasis in order to be responsive to new Western and national needs and priorities. These changing policies can still accommodate, however, the many areas in the West where there is need for rural development to build and stabilize the economy, to diminish rural decline, and offer some opportunities for inhibiting population movement into the more congested areas.

In the absence of clear-cut national direction, and the severe impacts that would accompany any long-term shortages of agricultural commodities, contingency planning for future food and fiber needs calls for continued development of alternative water resource plans which incorporate federally supported irrigation. Development of such plans should be concentrated in those areas having substantial undeveloped water and land resources, and having potentials for combining irrigation with benefits from other purposes and objectives. Areas with low population density, and those exhibiting rural decline, instability and social deterioration among minority or disadvantaged groups, should be given high priority.

An independent study should be conducted by a non-Federal group of outstanding professionals in related fields of economics, business, agriculture, sociology, and environmental sciences, with participation and assistance by Federal entities as required, to analyze the Federal role in developing irrigation. This could well be done within the context of broader studies that consider the Federal role in the entire field of food and fiber production. Consideration should be given to future national and international food and fiber needs, and whether federally assisted irrigation projects would provide a useful tool to meet such social goals as rural development and population distribution.

Coordinated Land Use and Water Planning. – The development of water projects and programs has had tremendous influence on the character of Western development. Now emerging is a viewpoint that, considering the advanced development of the West and its changing economic character, water resource development will not play as dominant a role as in the past, and that land use will become the controlling factor with water use a necessary adjunct and service. It is evident that there will be much greater coordination of land use and water planning in the future than in the past.

In comparison to land use planning, procedures for water resources planning have been continually perfected over the past 40 years are now well established as reflected in the Principles and Standards, as published in the Federal Register on September 10, 1973, by the Water Resources Council. By contrast, land use planning has proceeded without nearly the intensive effort or central coordination given to water resources planning, and land use planning processes applied today are widely variable.

Before an acceptable land use planning process can be implemented, agreement must be reached on several important factors. These include methodology for evaluating land use needs; land suitability; methods for consideration of aesthetic and environmental values; and definition, identification, designation, and regulation of areas of critical concern – large-scale developments, key facilities, and areas of

State, regional, and national interests. Also general agreement is required on what constitutes an adequate data base for acceptable land use decisions and the approach to public participation in the planning process.

States have the basic constitutional authority for control of the use of private lands and a major influence in determining planning objectives and in the management of Federal lands within their State. Historically, states have delegated land use management authority to units of local government. In many instances, this has resulted in land use and management decisions based on expediency, tradition, and short-term economic considerations. Decisions by local interests normally are guided primarily by the impact of those decisions on their community. Land use decisions made by the Federal Government have not always included adequate and effective participation by State and local governments.

The need for coordinated land use planning has been widely recognized and the establishment of both Federal and State land use legislation has been gaining momentum throughout the Nation. All of the Western States have moved into some phase of land use regulation.

National land use legislation has been considered by the last two sessions of the Congress. It would provide financial assistance to the States, initially to establish a land use planning process and ultimately to implement that process. New legislation would complement and tie together recent legislation such as the National Environmental Policy Act of 1969, the Wild and Scenic Rivers Act of 1968, the Wilderness Act of 1964, the Land Sales Full Disclosure Act of 1968, the Agricultural and Consumer Protection Act of 1973, the Federal Water Pollution Control Act Amendments of 1972, the Clean Air Act of 1970, and the Coastal Zone Management Act of 1972. Federal legislation has been proposed which would have important impacts on Federal and State land use planning for such areas as land use policy assistance, nationwide strip mining control, powerplant siting, and Federal lands management. An ultimate product of this body of existing and pending legislation could be a national land use policy to guide both land and water planning.

Comprehensive land use planning requires full coordination with planning for water and related land use to eliminate present and future conflicts and competitions. Many of the conflicts which have centered around incompatible uses of the same land resource are the result of inadequate planning where important issues of priorities, goals, and objectives had not been decided clearly.

To further the objectives of adequate coordination of land and water use in the West (1) a national land use policy should be developed, (2) each state should develop a land use planning process in cooperation with the Federal agencies that have technical expertise and those that have responsibilities for management of Federal lands in the state, and (3) a Federal entity should be assigned responsibility for nationwide coordination of land use and water planning efforts.

Flood Plain Management. – Flood plain management programs are finding greater and greater acceptance. Increases in annual flood damages are primarily due to growth in flood plains and in part to increasing values in existing development. The way to halt or decrease these ever-increasing damage costs, while recognizing natural resource values, is flood plain management which achieves or strives for appropriate use through a whole mix of traditional structural measures and non-structural measures.

Potential solutions for a specific problem site will vary with the economics of each flood plain and its relationship to the alternative plans of land use for the entire community or region. Measures employed in addition to detention or retention reservoirs, dikes, levees, channels and diversions include such measures as land use adjustments, flood warning systems with temporary evacuation, permanent evacuation, flood proofing, flood insurance of specific properties, zoning, and acquisition. There are often opportunities in flood plain areas for

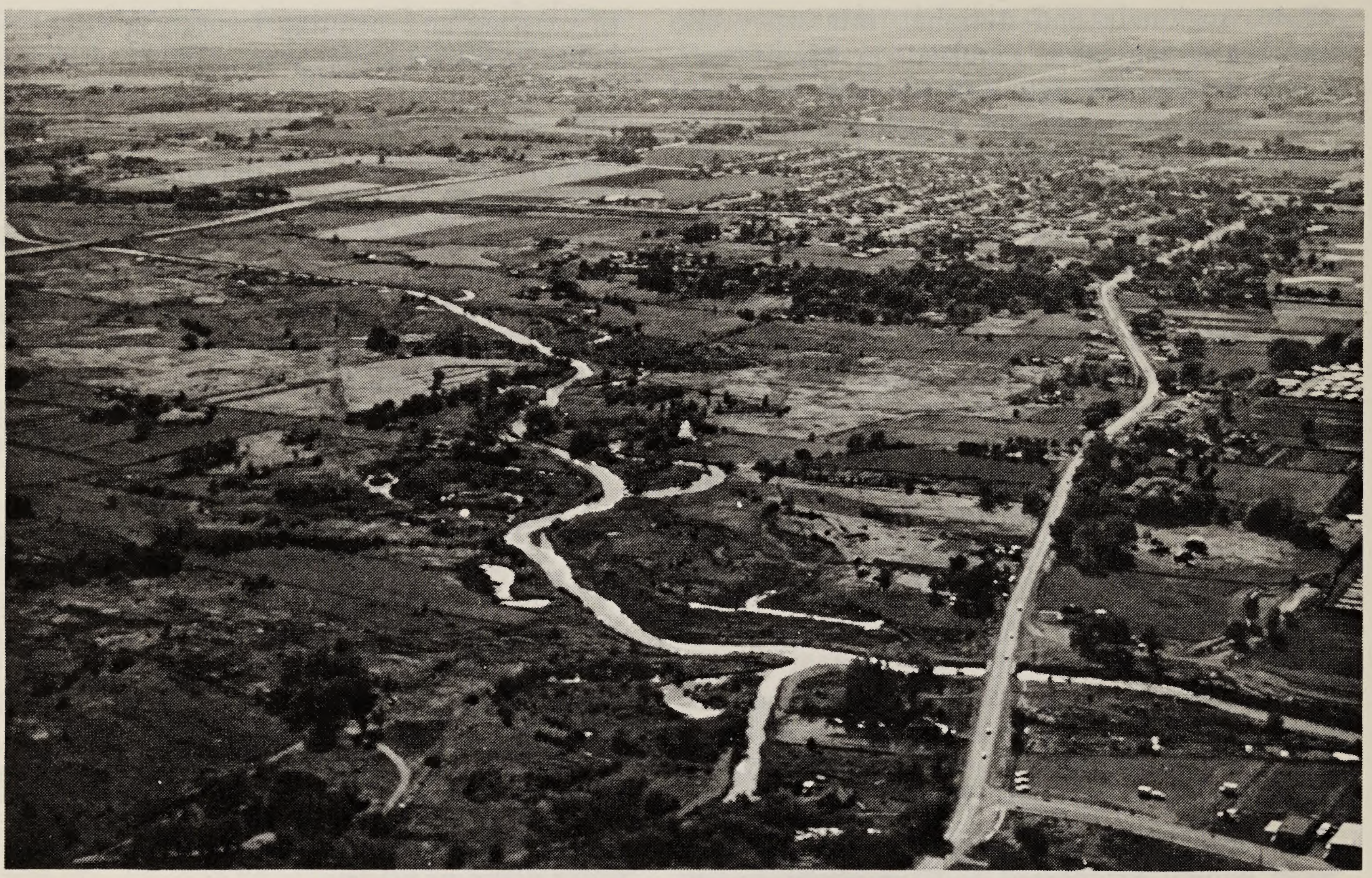


Figure 16. Jordan River flood plain management area – Utah.

natural parks and greenbelts which provide recreational activities and restore urban beauty. Whether adjustments are traditional (modify floods) or nontraditional, they must protect or enhance natural flood plain resource attributes to the extent possible.

By the end of September 1973, 234 places in the 11 Western States had adopted some form of flood plain regulations. Montana and Arizona have recently adopted statewide flood plain management programs. The States of Washington and California have programs which encourage the adoption of flood plain regulations; Oregon and Colorado are working in that direction.

Both the Corps of Engineers and the Soil Conservation Service are authorized to provide information and other assistance to States and local areas in formulating flood plain management programs, but the heaviest burden of responsibility, and often the costs involved, presently falls upon local and State governments. Requests for Federal services have exceeded the funding and capabilities to respond. This causes delays in the States and local efforts to effect flood plain management programs.

There is need for expansion of Federal service programs. The relatively small Federal expenditures involved in providing flood plain information and followup services may obviate large future expenditures for damages, disaster relief, subsidized insurance, and flood control measures. On the part of the State and local governments, a priority need exists for land use regulations.

REGIONAL PROBLEMS AND ISSUES

There are a number of critical problems and issues in the 11 Western States that, while not Westwide in scope, do involve two or more States or a major river basin. These have been classified as regional problems, of which nine have been identified. Four of these are centered in the Colorado River Basin and involve Colorado River salinity, Colorado River water supply, lower Colorado River management, and oil shale development in the Upper Colorado River Basin. Four occur in the Columbia River Basin and involve total water management of the Columbia River system, the Columbia River estuary, the Middle Snake River Canyon controversy, and erosion in the Palouse area. The ninth regional problem pertains to anadromous fisheries in the Pacific Northwest.

Colorado River Salinity. – As the waters of the Colorado River are put to consumptive use, the remaining waters are becoming progressively more saline, particularly in the lower reaches of the river. The concentrations of dissolved solids in the lower mainstream are already approaching the threshold limits for some uses. The primary agricultural impacts of increasing salinity will be in the Imperial, Coachella, Gila, and Yuma Valleys where a wide diversity of crops is produced. Adverse effects will also be experienced in Mexico. The primary impacts on municipal and industrial water supply will affect the Metropolitan Water District of southern California, the Las Vegas service area, and upon completion of the Central Arizona project the Phoenix and Tucson metropolitan areas.

The adverse effects of increasing salinity are primarily economic in character and confined to the consumptive uses of water. Instream uses of water for hydroelectric power production, for recreation, for fish and wildlife, and for overall environmental purposes will not be significantly affected. Recent studies by the Bureau of Reclamation estimated total annual direct and indirect economic losses of about $230,000 for each part per million of future increase in salinity of the Colorado River at Imperial Dam. Taking as a base the acceptable salinity levels of 500 p/m for municipal and industrial supplies and 750 p/m for agricultural use, the total damages attributable to salinity in the Colorado River system for 1973 were about $53 million. By the year 2000 these damages to the total regional economy are expected to reach $124 million per year if no control measures are applied.

The 1972 Joint Federal-State Enforcement Conference on the matter of pollution of the interstate water of the Colorado River and its tributaries initiated new efforts to establish an overall salinity control policy for the river. The seven basin State conferees and Federal representatives concluded that such a policy should have as its objective the maintenance of salinity concentration at or below levels found in the lower main stem while the upper basin continues to develop its compact apportioned water. The 1972 Federal Water Pollution Control Act Amendments have been interpreted by the Environmental Protection Agency to require the establishment of numerical salinity standards on the Colorado River. Another related matter that highlights the need for basinwide salinity controls is a recently executed agreement with Mexico to resolve the international salinity problem with Mexico. Under that agreement, water delivered to Mexico shall have an average annual salinity of no more than 115 p/m (plus or minus 30 p/m) over the average annual salinity of waters arriving at Imperial Dam.

Adequate studies have not been completed to identify accurately the quantitative contribution of salinity concentrations from various sources in the basin, but the order of magnitude is (1) natural sources, (2) irrigation sources, (3) reservoir evaporation, (4) out-of-basin export, and (5) municipal and industrial sources.

Solutions to the salinity problems on the Colorado River will result from the cooperative efforts of all involved Federal, State, and local agencies and organizations. The primary study

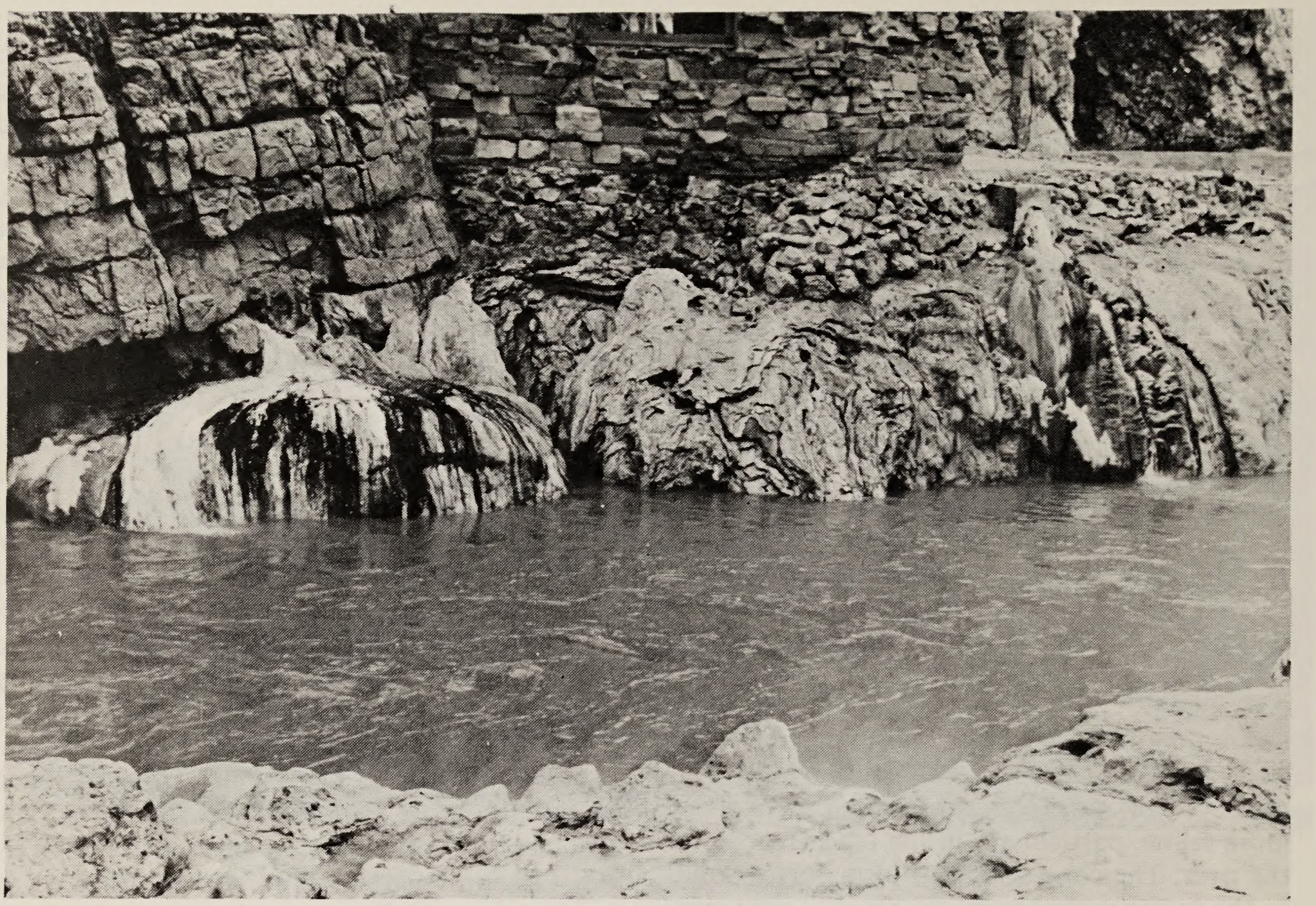


Figure 17. LaVerkin Springs discharging highly saline water into Virgin River, Utah.

effort under way at this time is the Bureau of Reclamation's Colorado River Water Quality Improvement Program (CRWQIP).

Working with several of the States involved, a comprehensive investigation program was structured and launched by the Bureau of Reclamation in FY 1972. Emphasis is placed on controlling salinity from irrigation, diffuse and point sources. Nonstructural measures, such as improving irrigation efficiency, river system management, water system management and utilizing return flows, are being given prime consideration. Other techniques such as structural control of point sources, weather modification, desalting of seawater and geothermal brines, land and vegetation management, erosion control, and waste-water utilization, are undergoing additional research and development to identify their prospects for water quality improvement.

An impressive start towards solving the Colorado River salinity problem is provided by Public Law 93-320, the Colorado River Basin Salinity Control Act of June 24, 1974. Title I of the act authorizes a series of undertakings, including the construction of a desalting plant to treat approximately 129 million gallons per day of drain water from the Wellton-Mohawk division of the Gila project, Arizona, to carry out the commitments of the United States in its recent agreement with Mexico, Minute 242 of the International Boundary and Water Commission, United States and Mexico.

Title II of the act authorizes four salinity control units upstream from Imperial Dam as the initial stage of the Colorado River Basin salinity control program – the Paradox Valley and Grand Valley units in Colorado, the Crystal Geyser unit in Utah, and the Las Vegas

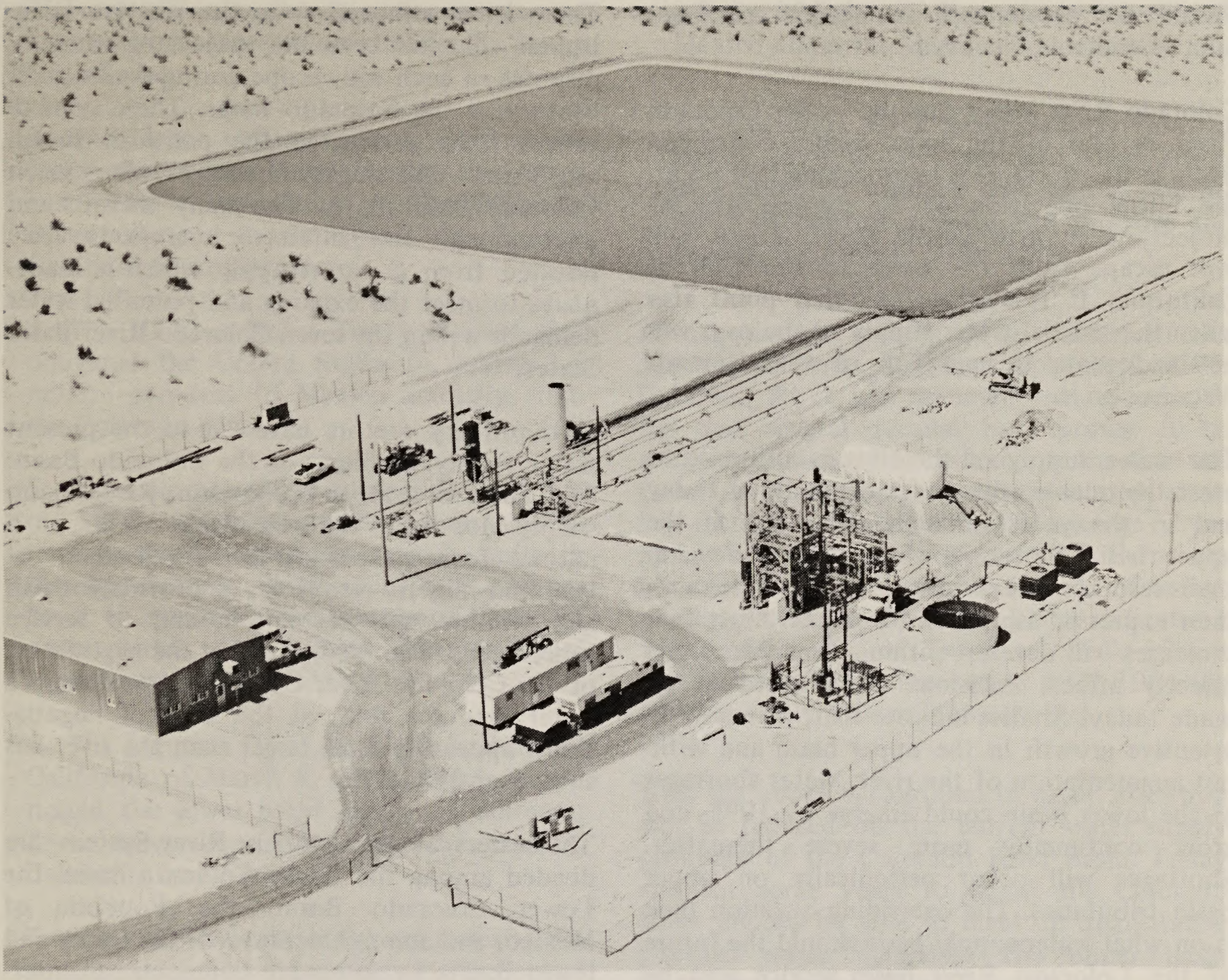


Figure 18. Geothermal test facility, Imperial Valley, California.

Wash unit in Nevada. Further, Title II prescribes that the costs of the initial units shall be allocated as follows: 75 percent to be nonreimbursable and 25 percent between the Upper Colorado River Basin Fund and the Lower Colorado River Basin Development Fund. The costs allocated to the Upper and Lower Basin funds are to be repaid without interest within 50 years from the date when each unit is in operation.

There is no one complete solution to the complex problem of salinity control in the Colorado River. A salinity control program should be regarded as but one element in a matrix of solutions which ultimately will form a comprehensive plan of management for the total water resources of the Colorado River Basin. Other elements include the planning and operation of interrelated structures, augmentation of the river, possible legal and institutional changes, new management techniques, increased efficiency in present use, and future development of basin water resources.

The Colorado River Water Quality Improvement Program should be continued on an accelerated basis to implement those investigations or programs that are considered cost effective and demonstrate immediate program benefits. Related programs of the Environmental Protection Agency, Department of Agriculture and Land Management agencies should be accelerated as needed to meet salinity control objectives.

Colorado River Water Supply. – The Colorado River is one of the most highly controlled rivers in the world. It is approaching that point, the initial operation of the Central Arizona project, when little usable water, if any, will ever escape from the basin to the Gulf of California. It is approaching that point also when the natural water supply of the river will be inadequate to meet all of the demands placed upon it.

The water supply of the river is adequate to meet the quantitative water demands of today and in the years immediately ahead. If the upper basin States, however, are to develop their resources at a rate commensurate with their expressed aspirations, it is a certainty that shortages will develop within a time frame that directly affects decisions which need to be made today. Studies indicate that, with a fairly intensive growth in the upper basin and without augmentation of the river, water shortages in the lower basin could emerge by 1995, and grow continually more severe thereafter. Shortages will occur periodically on upper basin tributaries. The overriding question then is on what water supply basis should the future of the Colorado River Basin service area be planned.

The Colorado River, supplying water to such metropolitan complexes as those along the coast of southern California, the Eastern Slope of the Rocky Mountains in Colorado, the Upper Rio Grande of New Mexico, and along the Wasatch Front in Utah, has a service area extending far beyond its physical drainage basin. In spite of its very meager water supply more water is exported from this system than from any other in the United States. More than half of the West's population is directly dependent on the Colorado River as a source of water.

The Colorado River is not only one of the most physically developed and controlled rivers in the Nation, it is also one of the most institutionally encompassed rivers in the country. There is no other river in the Western Hemisphere that has been the subject of so many disputes of such wide scope during the last half century as the Colorado River. These controversies have permeated the political, social, economic, and legal facets of the seven Colorado Basin States. The many lawsuits and interregional and interstate compacts have resulted from a water supply which is inadequate to meet the existing and potential water demands within the seven Colorado River Basin States.

Two primary factors have led to the present water supply problems of the Colorado Basin. The first is that the Colorado River Basin simply does not yield sufficient water on a natural basis to permit full development of land and mineral resources; to provide for fish and wildlife and recreation; and to service other needs. The second is that the negotiators of the Colorado River Compact apportioned a water resource that, at the time of negotiations, appeared much larger than the river has subsequently yielded.

The waters of the Colorado River System are divided among the Upper Colorado Basin, the Lower Colorado Basin, the Republic of Mexico, and among the States of the upper and lower basins by interstate compacts, an international treaty, a Supreme Court decision, and by State and Federal legislation. Additional Congressional legislation, agreements with Mexico, and other documents affect and, in some instances, dictate how the river shall be managed and operated. Collectively, these various agreements, guides and directives are known as the "Law of the River."

Major benchmarks in the "Law of the River" are:

1. The Colorado River Compact of 1922 which divided the waters of the Colorado River System between the upper and lower basins.

2. The Boulder Canyon Act of 1928 which authorized the construction of Hoover Dam and Powerplant and the All-American Canal.

The act also sets the stage for division of lower mainstream waters among the lower basin States.

3. The Upper Colorado River Compact of 1948 that apportioned among the upper basin States the waters of the Colorado River allocated to the upper basin by the Colorado River Compact.

4. The Mexican Water Treaty of 1944 that obligated the United States to deliver 1.5 million acre-feet to Mexico annually from the Colorado River.

5. The Colorado River Storage Project Act of 1965 which authorized several long-term carryover reservoir storage units in the upper basin which permit the upper basin to maximize the consumptive use of water within its Colorado River Compact apportionment.

6. The Supreme Court Decree in Arizona vs. California of March 9, 1964, which apportioned the lower basin supply of Colorado River water among the States of Arizona, California, and Nevada.

7. Colorado River Basin Project Act of 1968 which directed that diversions to the Central Arizona project in times of shortage shall be so limited as to, in effect, guarantee California the use of 4.4 million acre-feet of Colorado River water annually. It also declared that the satisfaction of the Mexican Water Treaty from the Colorado River constitutes a national obligation which shall be the first obligation of any water augmentation project planned pursuant to the act.

8. The Federal Water Pollution Control Amendments Act of 1972 which gives the Environmental Protection Agency certain responsibilities and authorities for controlling water quality on the Nation's rivers.

9. Minute 242 (1973) of the International Boundary and Water Commission, United States and Mexico, which requires the initiation of several actions which will reduce the salinity of Colorado River water deliveries to Mexico under the Mexican Water Treaty.

10. Colorado River Basin Salinity Control Act of 1974, which authorized construction of a desalting complex and salinity control units to control salinity and improve the quality of Colorado River water.

In negotiations leading to a number of the above documents, a water supply yield of the Colorado River was assumed that records of the past several decades have proven to be overly optimistic. For instance, at the time the Colorado River Compact was negotiated, existing records indicated that the average virgin runoff of the Colorado River at Lee Ferry was in excess of 18 million acre-feet. As of today, the long-term record (1906-1970) indicates a virgin yield at Lee Ferry of 14.9 million acre-feet, while for the period 1931-1964 the yield was only 12.9 million acre-feet.

With the above background in mind, attention can be focused on the current water supply problems of the Colorado River Basin. Today and for some years to come, the Colorado River should be able to meet all quantitative physical water demands. The upper basin States are meeting their Compact requirements and demands being placed on the river are being met. Lake Powell and Lake Mead are filling and, assuming average annual runoff conditions for the next few years, Lake Powell and Lake Mead will "spill" in the sense that they will be required to release water, other than Mexican Treaty waters, for which there will be no consumptive use in the United States. However, assuming a long-term average annual supply of 14.9 million acre-feet, sometime after the Central Arizona project is fully operational, the Colorado River will not yield enough water under normal circumstances to meet upper and lower basin demands, the Mexican Treaty obligations, and system losses. Thus, the Colorado River Basin faces future water shortages unless its natural flows are augmented or water-dependent basin development is curtailed. The extent and timing of these shortages will depend on the rate of future consumptive use development and the volumes of annual runoff.

There are several categories of potential shortages:

1. When California is first cut back from its present 5.1 million acre-feet annual consumptive use to 4.4 million acre-feet consumptive use a legitimate current demand on the river will not be met in full because of limitations on basin water supply. Although California would still be receiving its basic Colorado River supply and even though it has available more expensive alternative supplies to offset the cutback, it could be said that a shortage exists;

2. At that time when the total annual water demands of the basin, including reservoir evaporation and other water losses, exceed the long-term average annual water supply, the basin will be in a water shortage status even though water demands could be met for a limited period by drawing on reservoir storage;

3. When Arizona must reduce its Colorado River consumptive uses below 2.8 million acre-feet per year a new shortage will occur;

4. When the upper basin reaches its assured annual consumptive use of 5.8 million acre-feet annually, a still different type of shortage will be reached. (The 5.8 million acre-feet annually is that assured amount remaining for use in the upper basin under adverse runoff conditions after it has met its obligation to deliver 75 million acre-feet to the lower basin each 10 years and if it is required to contribute 750,000 acre-feet annually toward meeting the Mexican Water Treaty obligation. The assured supply thus estimated is not to be construed as the limit of the upper basin apportionment, as it is recognized that there is not agreement among the States of the Colorado River Basin on how the Mexican Treaty obligation is to be shared prior to the time augmentation of the Colorado River is accomplished under the terms of the Colorado River Basin Act of 1968). Because of the long-term carry-over storage of Lake Mead and the upper basin storage project reservoirs, whenever shortages occur in the above categories such shortages likely will span several years;

5. Another category of shortage common to the river systems can occur in the upper basin tributaries above main storage units where the water supplies are not sufficiently regulated by long-term carry-over storage. In these circumstances, shortages can vary from as little as a month at a time to a year or more; and

6. Still another category of shortage is represented by the Gila River basin where the present consumptive uses far exceed the combined surface and ground-water recharge of the basin. A shortage has existed here for years.

To help predict future situations relating to both water supply shortages and water quality under varying assumptions, a mathematical model of the Colorado River referred to as the Colorado River Simulation Model (CRSM) was developed. The model receives projected hydrologic sequences and projected water demands, processes them through a comprehensive systems operation, and evaluates the results in terms of water supply versus water demand.

To explore various possible future Colorado River runoff conditions, hydrologic traces, or theoretical 30-year sequences of Colorado River flow, are generated for selected stations over the entire Colorado River Basin based on statistical parameters derived from historical data and modified as necessary to reflect the runoff period of 1914-65. This period of record was selected because the modified flow analysis for benchmark gaging stations was available. These data were prepared for the Upper Colorado Region Comprehensive Framework Study.

An almost infinite number of hydrologic traces can be generated. For the purpose of illustrating a range of possible future runoff sequences three hydrologic traces were structured. Trace A reflects a reasonably low runoff cycle with a 30-year mean estimated virgin flow at Lee Ferry of 13.2 million acre-feet. Trace C reflects a reasonably high runoff cycle of 15.5 million acre-feet. Trace B (14.1 million acre-feet) reflects a reasonable intermediate situation.

Alternative Future Water Demand Schedules.— The element of uncertainty in projecting the rate at which future water demands in the Colorado River Basin will occur is limited almost exclusively to the upper basin. In the lower basin the major important factor is the date that the Central Arizona project will start to divert water. Thereafter, Arizona and California will be diverting water to the limits of their entitlements. Projects for Nevada involve relatively small quantities. Thus, the future pattern of deliveries to the states in the lower basin is firmly established.

By contrast current upper basin uses are well below the assured upper basin water supply. This situation permits significant expansion of consumptive use before the upper basin reaches the ceiling attainable within the Compact. The rate of which upper basin water demands will grow depends upon several factors – the rate at which authorized Federal projects in the upper basin will be constructed and put into operation; the rate at which oil shale, coal and other energy resources are exploited; the rate at which municipal and industrial uses will expand; the level of conversion of water now used for irrigation to other purposes; and the future availability of water.

To illustrate a range of possible future water demands, three alternative water demand schedules through the year 2000 were structured.

Alternative 1 projects a reasonably slow rate of future water demand buildup in the basin. It provides for a low level of Federal project construction and for limited future water demands to service energy resource development in the upper basin. The Central Arizona project is estimated to divert water initially in 1987. Specifically alternative 1 provides that, in addition to the Federal projects currently under construction (Navajo Indian Irrigation Project; Bonneville Unit, Central Utah project; and the Fryingpan-Arkansas project), the five upper basin projects authorized in the Colorado River Basin Project Act would be constructed and in operation by 1987. It provides for a total of 22,630 MW of thermal power, 1,797 million cubic feet per day of coal gasification capacity, and the production of 680,000 barrels of oil per day from oil shale. All other functions and non-Federal development were projected to increase at a restricted rate.

Alternative 2 is a middle-ground projection. It anticipates a moderate level of Federal project construction and a moderate increase in water demands to serve energy resource development in the upper basin. It projects initial Central Arizona project diversions in 1987. Specifically, it provides that, in addition to the Federal projects included in alternative 1, the Lyman project would be constructed by 1980 and some Ute Indian deferral lands and the Jensen unit of the Central Utah project would be constructed by 1995. Thermal power development increased to 28,060 MW, coal gasification capacity to 2,373 million cubic feet per day and oil production from oil shale to 1,315,000 barrels per day.

Alternative 3 projects a high level of future construction of Federal projects in the upper basin together with sharply increasing water demands to service development of energy resources in the upper basin. It projects initial diversions from the Central Arizona project by 1985. Thus, alternative 3 represents a reasonably high projection of future basin water demands. Specifically it provides for the construction of all Federal projects now authorized except those authorized in the Colorado River Basin Salinity Control Act of 1974 which have little effect on water quantities. Thermal power development increases to 32,560 MW. Coal gasification capacity is at 2,911 million cubic feet per day and oil production from oil shale is at 1,515,000 barrels per day. Other demands are also increased substantially.

In developing these alternative water demand schedules, extensive use was made of information in the Upper Colorado Region Comprehensive Framework Study. The projections of water demands for the energy function of thermal coal power generation, coal gasification and oil production from oil shale were based largely on information in the Report on Water for Energy in the Upper Colorado River Basin, prepared by the U.S. Department of the Interior.

It should be noted that for alternative 1 only those plants reasonably sure of development were included and none subsequent to 1985 were included. For alternative 2 no plants subsequent to 1988 were projected but for alternative 3 potential plants through the year 2000 were included.

The three alternatives reflect three different rates of increase in future upper basin water use and are intended only for illustrative purposes to demonstrate the adequacy or inadequacy of Colorado River water supply under varying assumptions as to basin runoff and basin water demand. Consideration was not given as to whether projected water demands in the upper basin would exceed the upper basin's assured supply or whether such demands in any given state would exceed the state's allocation of upper basin water. It is realized that should such an event occur compensating steps would be necessary or water-based development restricted.

Water demand levels in the Lower Colorado River Basin reflect two future situations: prior to initial operation of the Central Arizona project and subsequent to initial operation. In the former situation, full demand levels can be met within compact and other limitations, whereas in the latter case, full demand levels by Arizona and California cannot always be met because of water supply limitations.

Results of Model Runs. – The Colorado River Simulation Model is in its trail stages. With the change from a single historical runoff sequence to several theoretically possible sequences, more testing will be required before there can be complete confidence in its operation and the answers it provides. The results given hereafter, thus, should be considered preliminary and subject to further analysis. They are, however, considered adequate for the purpose intended – that of demonstrating the adequacy or inadequacy of Colorado River water supply under varying future conditions.

The model operation assumed upper basin deliveries at Lee Ferry of at least 8.25 million acre-feet annually. It took into account all inflow and reservoir and river losses below Lee Ferry. It followed the operating criteria promulgated under provisions of Section 602(a) of the Colorado River Basin Project Act and accommodated the flood control operating criteria established by the Corps of Engineers. It recognized surplus and shortage levels at Lake Mead which governed the amount of releases for lower basin consumptive uses.

With three different projected runoff sequences and three different projected levels of basin water demand buildup, nine different patterns of future water supply-water demand situations were delineated through the model runs.

The combination of Trace A (low runoff) and Alternative 3 (high-water demands) presents an extremely poor picture of future water supply adequacy. While the situation portrayed by this combination could occur the chances of it materializing are quite small.

By combining Trace C (high runoff after CAP) with Alternative 1 (low-water demands) a highly favorable picture of future water supply adequacy is presented. The chances of this combination occurring likewise are quite small but probably not as remote as the Trace A – Alternative 1 combination.

The combination of Trace B – Alternative 2 presents a reasonable middle-ground picture.

The following table summarizes the results of the model runs for the three alternative

Results of model runs — Colorado River

Alternative demands and hydrologic traces	Estimated 30-year average annual virgin water supply at Lees Ferry (Million acre-feet)	Year CAP on line	Shortage conditions				End of month contents December 2000	
			(1) California consumptive use cut back to 4.4 million acre-feet per year	(2) Year total basin water demands exceed long-term average virgin flow of 14.9 million acre-feet	(3) Arizona consumptive use reduced to less than 2.8 million acre-feet per year	(4) Year upper basin demands equal to 5.8 million acre-feet	Lake Powell (million acre-feet)	Lake Mead (million acre-feet)
ALT-1		1987						
A	13.2		1994	—	—	—	17.2	20.1
B	14.1		1988	—	1999	—	16.3	20.1
C	15.5		—	1987	—	—	25.7	26.4
ALT-2		1987						
A	13.2		1989	1987	—	—	15.8	18.7
B	14.1		1987	1988	1999		16.4	18.2
C	15.5		—	1987	—	—	25.6	26.5
ALT-3		1975						
A	13.2		1985	1987	2000	1993	12.9	16.0
B	14.1		1985	1988	1995	1995	14.0	14.7
C	15.5		—[1]	1985	—	1989	24.1	25.6

[1] In 1998 California was cut back to 4.4 million acre-feet, however, deliveries were greater than 4.4 million acre-feet the following two years.

demand schedules matched against the three hydrologic traces.

The results of the model runs support the following observations:

1. Total basin water demands in all likelihood will exceed the long-term virgin flow of the Colorado River in the 1985-1988 time frame, coincidental with study projection dates for completion of the Central Arizona project.

2. Upper Basin water demands under the high-level growth projection could equal or exceed 5.8 million acre-feet in the 1990-1995 time period. However, in most cases, because of favorable runoff or storage conditions, the projected demands were met until after the year 2000.

3. Except under a runoff cycle higher than the long-term average, California's current water use will be cut back to 4.4 million acre-feet some time between 1985 and 1995, depending upon basin water demand growth and hydrologic conditions.

4. Except under a runoff cycle higher than the long-term average, Arizona's consumptive use could be reduced below 2.8 million acre-feet some time within the 1995-2000 time period, depending upon basin water demand growth and hydrologic conditions.

5. Should the virgin runoff at Lee Ferry for the next 25 years average 15.5 million acre feet, all reasonably foreseeable basin water demands could be met through 2000, and both Lake Powell and Lake Mead would be full at that time.

6. Under any future runoff cycle other than an extremely adverse one, it is reasonably certain that the main Colorado River storage reservoirs will be full or nearly so when the Central Arizona project initially diverts water. By drawing on reservoir storage, the basic water demands of the basin under most circumstances could be met at least through the year 1995. However, by the year 2000 reservoir storage could be sorely depleted or exhausted, depending upon actual hydrologic conditions and the growth of upper basin water demands. After that date, serious water shortages could be common

except in periods of high runoff conditions. The basic keys to the extent and timing of future Colorado River water shortages are the runoff patterns and rates of growth of upper basin water demands after the Central Arizona project is completed.

In coping with the problem of potential future shortages, attention first should be directed to maximizing the yield and optimizing the use of the natural water supply of the Colorado River Basin consistent with environmental considerations. This can best be accomplished through a total water management program that includes such activities as coordinated operation of all major basin structures, conjunctive use of surface and ground-water supplies, increased irrigation efficiency, water salvage, and wastewater reclamation and reuse. Potential savings by these means could increase present supplies of the Colorado River by as much as 300,000 acre-feet annually.

It is evident that a total water management program can only delay and not prevent water shortages from occurring eventually. When such shortages do occur, there appear to be two alternative courses open.

The first would be to accept the limitation in water supply and pattern the economic and social future of the basin to that limitation. Such a situation could arise either from the desire of basin residents to restrict water-dependent developments or through the impracticality of augmentation for physical, economic, environmental, national policy, or other reasons. Under this option, there would still be choices of controlling the future economy of the basin through the transfer of irrigation water to other uses such as energy resource development, municipal and industrial, and recreation.

The second option would be to augment the flows of the Colorado River thus increasing its water supply and permitting continued growth of water-dependent development. Study has been given as part of the Westwide endeavor to means by which the river could be augmented including weather modification, desalting of seawater, and desalting of geothermal brines. Importation of water from resource regions outside the seven basin States was not considered in the Westwide Study because of restrictions on import studies contained in the Colorado River Basin Project Act. Although physically possible, importation of water to the Colorado River from other basins in the seven basin States does not appear practical.

Weather modification, from both a technical and economic viewpoint, appears to be a viable means of augmenting Colorado River runoff by from 0.9 to 1.3 million acre-feet annually. Social, legal, and environmental problems, however, remain to be resolved. Desalting of geothermal brines, although costly, may have augmentation potential. A decision point has not yet been reached on either its technical or economic feasibility. Desalting of seawater at this time appears to be too expensive to merit serious consideration as a source of large-scale augmentation.

To assist in resolving the water supply problems of the Colorado River Basin:

1. The total water management concept for the entire Colorado River Basin should continue to be broadened and perfected.

2. There should be an acceleration of programs of assistance to water users which would bring about the adoption of water management methods and practices to improve the efficiency of water use.

3. In conjunction with the States and other interested parties, a wide range of future water demand schedules for both options should be projected to be matched on the Colorado River Simulation Model with varied projected hydrologic sequences and operating criteria to provide information on the extent and timing of potential future water shortages.

4. Investigations and activities to delineate the most appropriate means of augmenting the Colorado River as envisioned in the

Colorado River Basin Project Act of 1968, should be given the highest priority.

a. The weather modification program of the Bureau of Reclamation should be continued aggressively with emphasis on resolving remaining sociological, legal, and environmental problems. A demonstration program of several years' duration, as presently proposed under the weather modification program, should be initiated in the Upper Colorado River Basin as soon as practicable to verify the findings to date, particularly as to the magnitude of increases and results of the weather modification program in runoff.

b. The ongoing geothermal desalting program of the Bureau of Reclamation on the East Mesa of Imperial Valley should be continued aggressively.

c. Other means of augmentation such as the importation of surface water, directly or by exchange, should be investigated as early as such studies would be appropriate and justified.

Lower Colorado River Main Stem Management. – The Colorado River from Lake Mead to its mouth has undergone more change in its physical characteristics and patterns of land and water use since completion of Hoover Dam in 1936 than any other major river in the Nation. These changes have created an urgent need for a comprehensive coordinated lower river water and related land management plan and operation.

Prior to Hoover Dam, the lower river was uncontrolled, alternating between massive floods in the spring and early summer and meager flows in the late summer and fall, a traditional feast or famine situation. The area was sparsely populated and the river was little used except for limited irrigation diversion when water was available and diversion structures hadn't been destroyed by spring floods. It was an area more suited for wildlife than for human occupancy.

Following construction of Hoover Dam and other major lower river regulatory and control structures, the character of the river and its uses changed radically. Today, the river is almost completely controlled. While still supporting important fish and wildlife populations, it has also become a center of intense human occupancy and activity. Recreation use of the river has burgeoned. More than 12 million people live within 4 hours driving time of the lower Colorado River and, during 1973, 8 million visitor-days of recreational use were recorded there. Urban and recreational home development along the main stem continues at an increasing pace. Much of the rapidly growing population growth in the area occurs along the river valley downstream from Davis Dam where the communities of Bullhead City, Havasu City, Parker, and Yuma in Arizona, and Blythe and Needles in California are located. Waste disposal associated with spreading population presents a water quality hazard.

Several reaches of the river below Davis Dam still remain relatively undeveloped. These areas have some of the best fish habitat along the river and provide many thousands of man-days of fishing each year. Water and heavy vegetative growth throughout the bottomlands provide a favorable wildlife habitat, with animal life concentrated in and adjacent to thickets. Marshlands provide a habitat which is rare in the arid Southwest and support many species of resident and migratory wildlife. In addition to the numerous game and species, several endangered species depend upon these areas. The preservation of this favorable habitat and its abundant wildlife is essential to the environmental quality of the valley. The important Imperial and Havasu National Wildlife Refuges are located here. Channelization of the river and phreatophyte control to conserve and salvage water have, in the past, conflicted with fish and wildlife management objectives. Reaches of the river have been identified as having potential for designation under the National Wild and Scenic River Act.

Irrigation is important with over 300,000 acres being irrigated along the river in Arizona and California. Water is diverted here also in

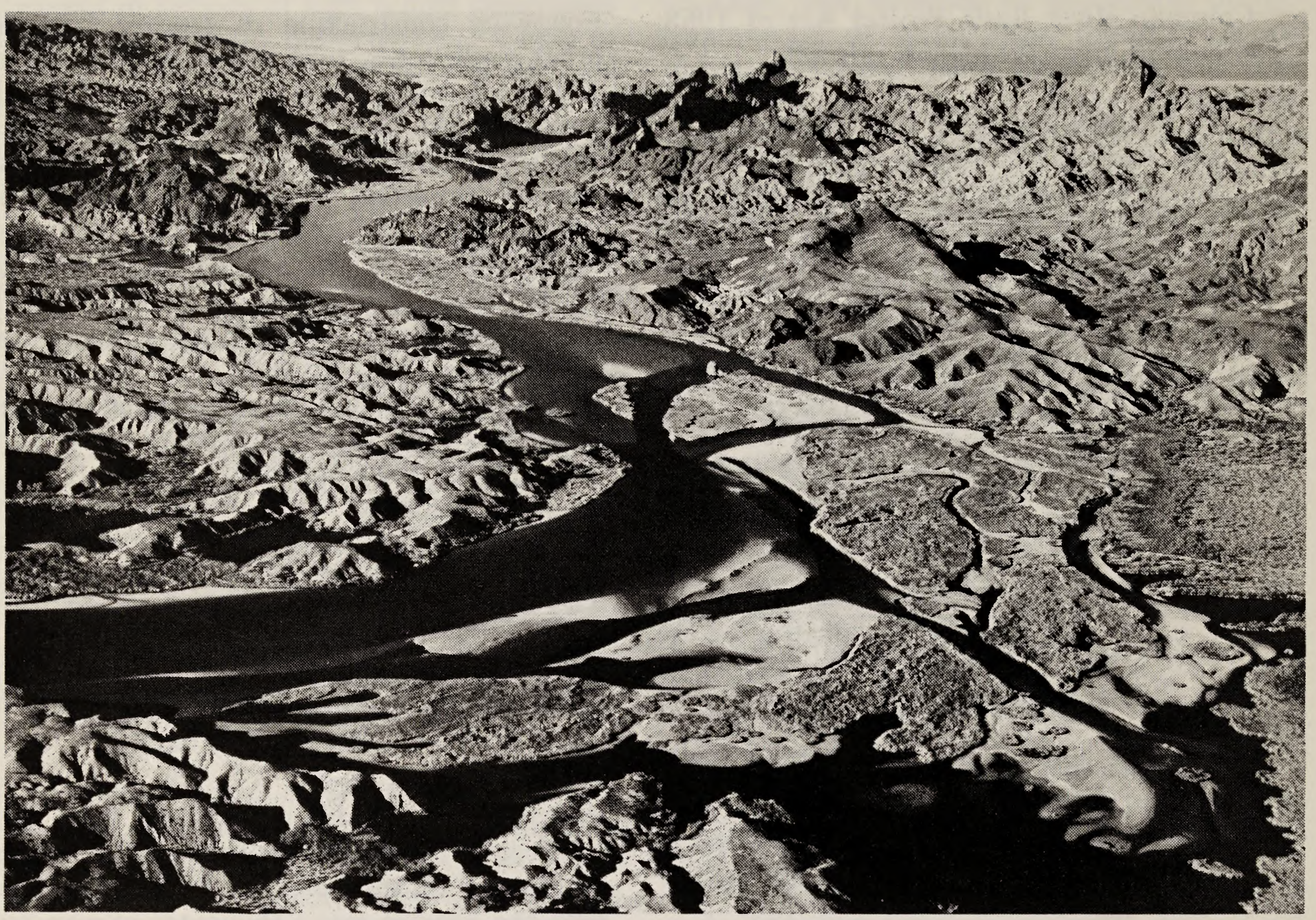


Figure 19. Undeveloped river reach, Topock Gorge area, Lower Colorado River main stem.

irrigated lands in the Imperial and Coachella Valleys of California. The Colorado River, Yuma, Chemehuevi, and Mojave Indian Reservations are developing facilities to utilize their remaining shares of Colorado River water through expansion of irrigation, recreation, and urban development. Illegal land occupancy and diversion of flows for irrigation also are a problem.

The river is an important source of hydroelectric power for the Southwest with major power installations at Hoover, Parker, and Davis Dams. Numerous excellent sites exist for potential pumped-storage hydroelectrical installations. The siting of several nuclear powerplants in the area is under active consideration.

Downstream from Davis Dam more than three-fourths of the area bordering the river is in Federal ownership or Indian trust. As most of the remaining lands suitable for potential resort and community use are federally administered, there are increasing demands, supported by the States, that public lands be released for development.

The long list of the lower river's attributes, uses, and problems – several of which are competing or conflicting – calls strongly for a total water and related land-management plan. These uses, attributes, and problems include: natural scenic values; heavy and growing water-based recreational use; urban and community growth including attendant waste disposal problems; major existing and potential hydroelectric developments; potential nuclear plant siting; important fish and wildlife habitat and resources; endangered species; extensive irrigation development; illegal trespass and occupancy; important Indian reservations; water salvage potentials through channelization and vegetation control; extensive Federal land ownership; and water quality improvement.

There is a long history of Federal actions dealing with water and related land management problems along the lower Colorado River which have not always been consistent or had common objectives. Several Federal agencies have been involved, including the Bureau of Reclamation, Bureau of Land Management, Fish and Wildlife Service, Bureau of Indian Affairs, National Park Service, and, more recently, the Environmental Protection Agency.

Land use and management plans and proposals have been made by the Bureau of Land Management and by the Bureau of Reclamation within the past decade and the Bureau of Land Management is presently preparing a Management Framework Plan for lands which it administers. Even though a multiplicity of research, investigation, management, and implementation programs are underway by various Federal agencies, there is an urgent need to organize a multiagency, multidisciplinary group with sufficient authority to formulate a comprehensive long-range plan for the lower river and to establish the means for coordinating the various Federal, State, and local programs and activities in the area. Such a group should be basically a Federal-State group with opportunity for active public involvement and should include representatives of all State and Federal agencies having designated responsibilities in the area as well as representatives of other public interests.

Oil Shale Development in the Upper Colorado Region. – The recent energy crisis, with its widespread shortages of gasoline and fuel oil, has focused national attention on the extensive reserves of oil locked in the oil shales of Colorado, Utah, and Wyoming. The higher grade deposits cover about 16,000 to 17,000 square miles and contain about 600 billion barrels of extractable oil, enough to meet oil requirements of the United States for 100 years at present rates of consumption. These reserves are approximately 17 times the present U.S. (including Alaska) proved crude petroleum reserves. By States, 80 percent of the high-grade reserves are in Colorado, 15 percent in Utah, and 5 percent in Wyoming. Most of the reserves are on public lands, but there are also significant reserves on private lands.

To adequately assess the water problems associated with oil shale development, it is necessary to determine when development will start and the rate and ultimate level of development. Several projections have been made by various authorities and they range in production capacity by 1985 of from 450,000 bpd to 1,200,000 bpd.

Water requirements for oil shale production and processing vary with the production rate, mining techniques, and methods adopted for spent shale disposal. Municipal water for the increased population to support the oil shale activity would also be needed but would be relatively minor compared with other requirements. Total estimated water requirements vary between 5,000 and 20,000 acre-feet per year per 100,000 bpd production. On the basis of a projected industry output of 1 million bpd by 1985, the new water demands could vary between 50,000 and 200,000 acre-feet per year.

The Department of Interior's Final Environmental Impact Statement (EIS) for the Prototype Oil Shale Leasing Program assumes that oil shale development will take place in two phases: Phase I would be experimental, testing different mining techniques, land and water disposal, reclamation schemes, and environmental programs. In this phase, the three States are expected to produce, by 1983, about 500,000 bpd. Of this, 250,000 bpd would come from private lands in Colorado. Phase II is envisioned to evolve from Phase I research and development and thus could start between 1982 and 1986. Development would be continuous and dependent on Phase I technical results, the alternative cost of energy, extent of private development, environmental assessments, and other factors. About 500,000 bpd of capacity reasonably could be expected to be

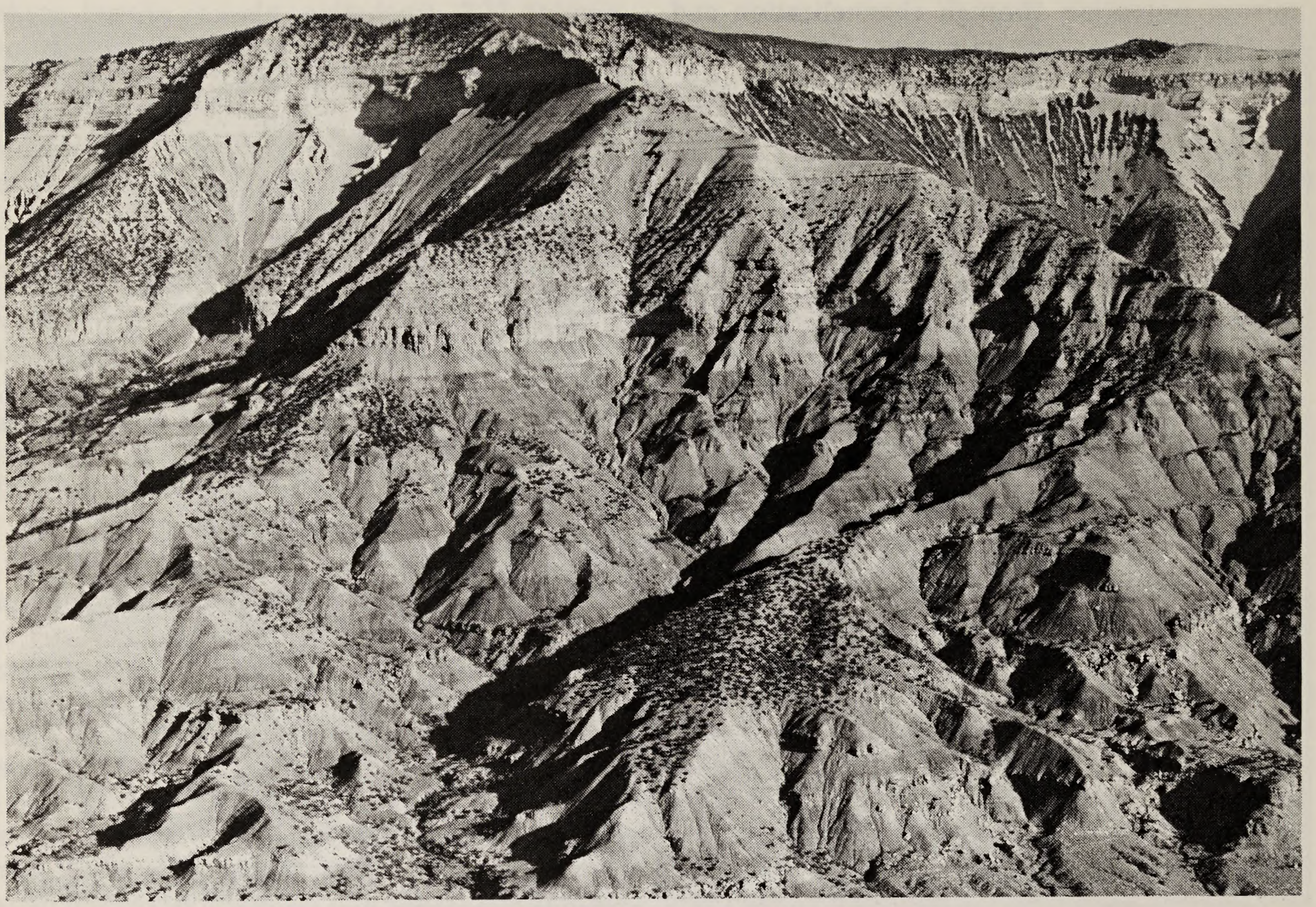


Figure 20. Oil shale cliffs along Colorado River near Grand Valley, Colorado.

added in the early stages of Phase II for a total oil shale industry production of 1 million bpd by 1987.

For Phase I development, no severe problems are anticipated in meeting water demands. As development expands, however, problems will arise. Sources of water that may be used are ground water, diversions from uncontrolled streams, existing Federal reservoirs, newly constructed storage facilities both Federal and non-Federal, and conversion of agricultural water use to industrial use. As development proceeds, other problems may involve Colorado River Compact limitations on total consumptive use within the upper basin States.

The July 1974 report of the Department of the Interior on "Water for Energy in the Upper Colorado River Basin" projects an oil shale industrial output of 1,515,000 barrels of crude oil per day by the year 2000 with accompanying water requirements of 259,000 acre-feet per year.

Oil shale production and processing will be accompanied by a number of significant impacts. Socioeconomic impacts related to population growth could place heavy burdens on the existing housing, school, and public service facilities of the area. Environmental impacts could affect winter range for deer, high-quality trout streams, wild and scenic rivers, endangered species, and general scenic values. Land impacts will be those directly involved with the amount and kinds of disturbances resulting from exploration, mining, processing, and spent shale disposal activities. There also will be a significant new demand for energy to serve production and processing activities.

Oil shale development in Colorado will have a major impact on water resources. Because the richest deposits of oil shale are between principal water aquifers or below the lower aquifer, large quantities of water may have to be pumped to keep the mines dry. Part of the ground water can be used in the processing of oil shale, but an excess of saline ground water probably will have to be pumped and disposed of during the lifetime of the operation. Release of excess saline water without treatment would increase the salt load downstream in the Colorado River. In addition, dewatering of mines could cause the flow of perennial streams in the vicinity to decrease or possibly to stop entirely.

For the new and potentially fast-growing oil shale industry, there needs to be close State-Federal monitoring of development plans, land reclamation plans, water supply proposals, and enviromental protection programs. More information and study are needed on the associated socioeconomic, environmental, land and water impacts. An interagency office, including State and local interests, should be established in the oil shale resource area to administer and coordinate those programs and activities necessary to the wise exploitation of the oil shale resource.

Total Water Management of the Columbia River System. – The Columbia River basin has undergone extensive development since the early 1930's. To date well over 100 major water resource development projects have been constructed by the Federal Government, State and local governments, private interests, and cooperative organizations.

Rapid economic and population growth of the region have imposed an ever-increasing demand on the system to produce more electric power, provide more recreation opportunities, better safeguard the fishery, obtain better control of floods, furnish more water for municipal and industrial use, and provide improved navigation. Many of these uses are not necessarily compatible. New public attitudes and Federal and State legislation concerning the environment, both natural and social-economic, also complicate the problem.

Operation and management of the far flung, many faceted, and many structured Columbia River System today under multiple Federal, State, and nongovernmental direction is not producing benefits compatible with the system's potential. An optimum river management system and development plan is needed so that all uses and desires including environmental considerations will benefit equitably.

The following are the major functions that would be most involved in a total water management plan:

Power. – The present Columbia River Power System is undergoing transition to an integrated hydrothermal system as commercial thermal generating plants are introduced into the region. The impact of possible changed patterns of fluctuations in flows and water surface elevations which could arise as hydroprojects carry more peak load must be evaluated.

Flood Control. – The reservoir storage and levee system, existing and under construction, provides a high degree of flood protection to the Columbia River main stem and can reduce peak flows of major floods on the lower river by approximately 50 percent. To enhance flood protection the flood control potential of reservoirs constructed for other purposes should be determined and consideration should be given to the desirability of transferring storage among reservoirs in the interest of economic efficiency or environmental enhancement. Nonstructural measures also should be considered.

Navigation. – Improvement of navigation through extension of the system, modification of restricting structures, deepening certain channels, improving recreational craft facilities, and adequately disposing of dredged materials are prime considerations.

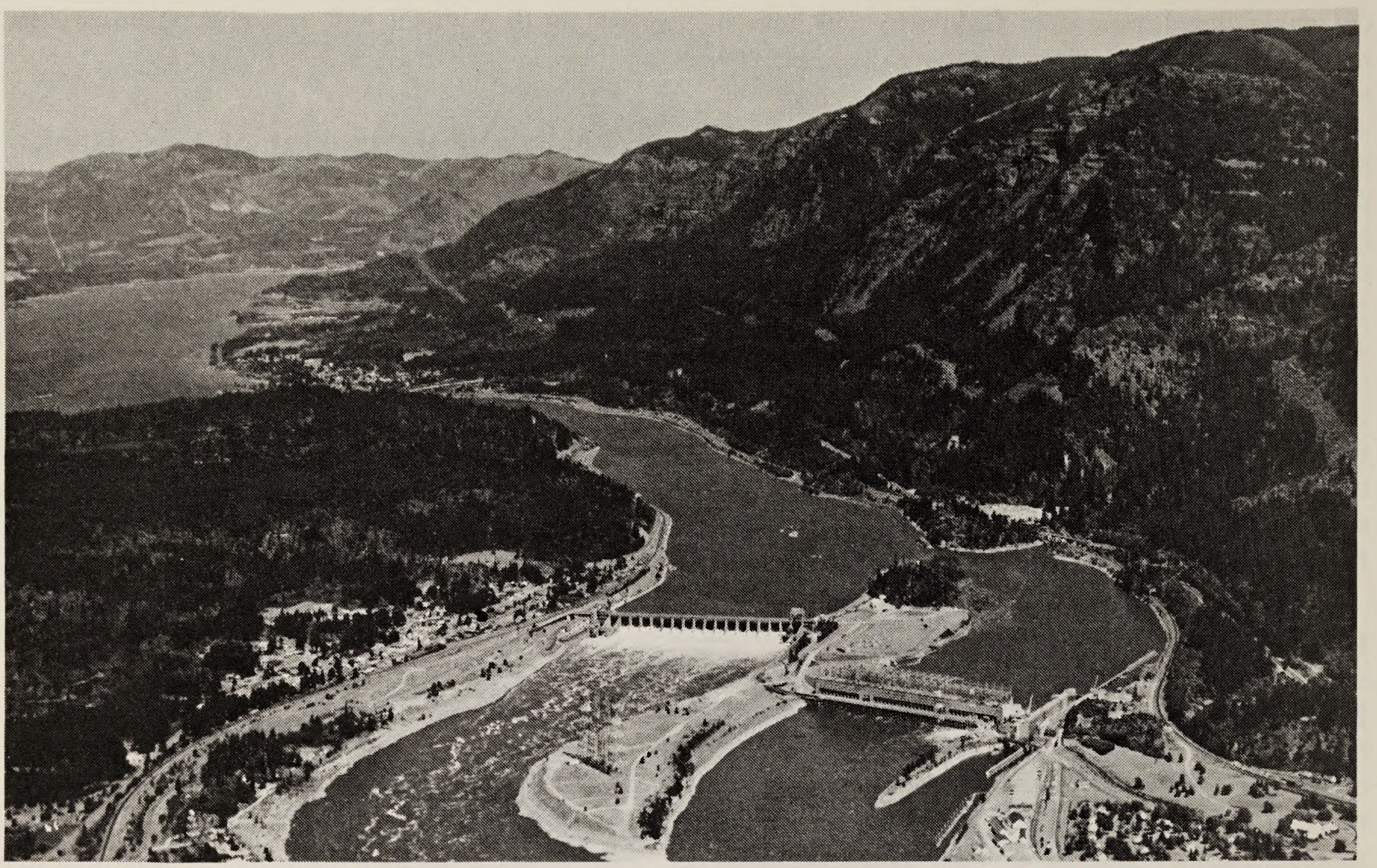


Figure 21. Bonneville Dam, Columbia River, Oregon-Washington.

Irrigation. – The irrigation function at both existing and proposed reservoirs should be reviewed and the potential for transfer of storage among reservoirs evaluated.

Fish and Wildlife. – The effects of peaking operations on the movement, spawning, survival, and harvest of anadromous and resident fish must be determined. Long-term solutions to reducing levels of nitrogen supersaturation must be determined and their relationship with present and potential future projects developed. Methods to preserve or enhance habitat consistent with other essential development should be developed and their relationship with present and potential future projects determined.

Recreation. – An overall regional master plan to meet recreational needs should be prepared and a determination made as to the part existing and planned projects contribute to the plan. There is a need for evaluation of further recreational development at existing projects and the effect of changes in project operation on recreation opportunity.

Water Quality. – Water quality problems occur in many tributary streams during periods of extreme low flows and below metropolitan areas. Water temperatures and nitrogen levels can affect anadromous fish on the main stem and major tributaries of the Columbia River System.

Columbia River Estuary. – As in any major river system flowing to the sea, an important relationship exists between conditions and activities in the river and in its estuary. The Columbia River estuary is treated immediately hereafter as a separate regional issue.

The magnitude and complexity of the overall Columbia River problems are such that no final permanent solution can be developed. Solutions and operating criteria developed must be flexible and adapted to a time frame for use.

The Corps of Engineers has underway a study entitled, "Columbia River and Tributaries" (CR&T). The main thrust of the CR&T study is towards analysis of the existing Columbia River System in consideration of today's needs, and it will emphasize the possibilities for modification of existing projects or their operation. The study will give equal recognition to all uses and purposes consistent with sound planning while examining all reasonable alternatives. The ongoing Corps study is scheduled for completion in FY 1978.

Although the Corps of Engineers CR&T Study can provide the basis for developing a total water management plan for the Columbia River main stem system, without a greater input of environmentally oriented interests adequate consideration of such interests may not be possible. In order to provide data and input to fill this environmental gap the Fish and Wildlife Services, the Bureau of Outdoor Recreation, and State agencies should be funded to participate in the study.

The Columbia River Estuary. – Major estuaries always have been susceptible to serious degradation because of the activities of man. The causes are two-fold. First, the major estuary is almost always a prime harbor site and thus the site of major population centers. Such centers along with commercial uses of the harbors not only are sources of polluting discharges into the estuary but they also completely change the natural environment of the shores of the estuary. Second, upstream development, with its attendant consumptive uses of water, not only depletes the natural river inflows to the estuary but adds also an imposing burden of pollutant discharges.

Figure 22. Winter waterfowl area in Columbia River estuary.

Fortunately for the Columbia River estuary the flows of the Columbia River are so large, 180 million acre-feet per year, that the degrading impacts of man's activities have not been as severe as in other major estuaries of the Nation. Unless, however, preventative steps are taken, the inexorable toll of increasing growth in the Columbia River basin will be reflected in the estuary.

The Columbia River estuary is the largest in the Pacific Northwest. It provides a major commercial ship artery for Columbia River ports. It is the entrance for the world famous runs of anadromous fishes, salmon and steelhead, to the Columbia River and tributaries. It is also the home of numerous types of animal and plant life. Competition between uses of the estuary maintained as closely as possible in its natural condition for recreation, cultural, aesthetic, and sport and commercial fisheries, and uses for development, commerce and industry is a major issue.

No comprehensive study has been made of the Columbia River estuary. Planning and inventory programs for the Columbia River estuary have lagged because of its large size and interstate nature. Neither Oregon nor Washington can independently plan for and manage this mutual resource.

Recent Federal and State legislation has given emphasis and priority to planning for the best use of coastal estuaries. Both the State of Oregon, through the recently established Land Conservation and Development Commission, and the State of Washington, through its Department of Ecology, are adequately organized to participate in coastal and estuary management studies. The impact of Federal programs, both in relation to commercial navigation within the estuary, and in the comprehensive system of river control structures upstream, is of paramount importance.

In view thereof, a special State-Federal study, coordinated by the Pacific Northwest River Basins Commission, should be undertaken for the Columbia River estuary with the objective of better defining the present status of the estuary and of preparing a planning and management plan and program to guide its future.

Middle Snake River Canyon. – The Snake River, in forming part of the boundary between Idaho and Oregon, winds its way northward through numerous rapids and deep pools in the deepest canyons in the world and one of the most spectacular gorges on the North American continent – Hells Canyon. The canyon has a solemn beauty, characterized by steep valley walls, prominent beaches in scattered locations, and occasional low sandbars. Hells Canyon also has exceptionally attractive hydroelectric potentials which, if developed, would open up extensive flat-water recreation opportunities in a spectacular canyon setting.

The problem thus presented is a classic example of a conflict between development and preservation. Structural development would be one or more storage dams, reservoirs, and powerplants primarily for the production of hydroelectric power, but with the capacity to serve other water resource purposes as well. Nonstructural development would be to designate and manage this reach as a wild and scenic river or a national recreation area. Preservation would dedicate this area to the enjoyment of future generations in its wild and untamed condition.

Plans and proposals to develop Hells Canyon for hydroelectric power go back at least 25 years, but the last decade is of primary relevance to the current problem. In 1964, the Federal Power Commission issued a license to the Pacific Northwest Power Company, a wholly owned subsidiary of four private Northwest power companies, for construction of the proposed High Mountain Sheep Project in the Canyon section. Legal action to enjoin the project led the U.S. Supreme Court in 1967 to remand the license back to the Federal Power Commission for further consideration of the alternatives of Federal construction or preservation of the reach of the river in free-flowing conditions. In 1968 the Department of the Interior reported on a multiagency resource study which appraised alternative development

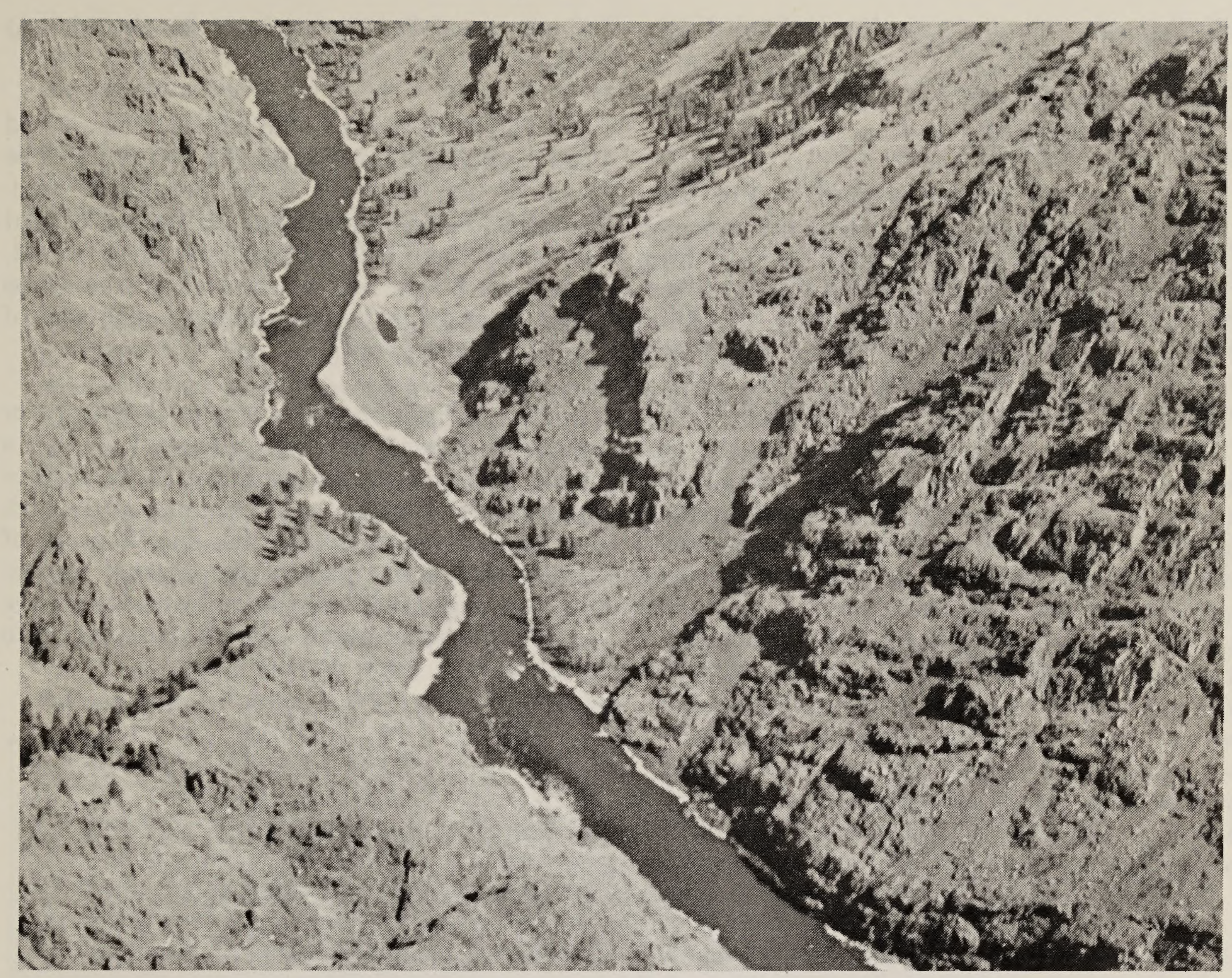


Figure 23. Aerial of Middle Snake River Hells Canyon.

at five sites. The report made no recommendation for development but favored delay for further study of nonstructural approaches. In 1968 also, the Pacific Northwest Power Company and the Washington Public Power Supply System, an operating agency composed of 16 public utility districts in Washington, filed a joint application with the Federal Power Commission for a project with alternatives to High Mountain Sheep. On February 23, 1971, the hearing examiner of the Federal Power Commission ruled favorably on this application with the condition that construction could not begin before September 11, 1975.

In the meantime, numerous proposals to preserve the river in its free-flowing condition have been made in the Congress. Bills to establish a Hells Canyon-Snake National River have been introduced every year since 1970. Bills also have been introduced to establish a Hells Canyon National Forest Recreation Area, and to establish a moratorium on development of storage projects in the Middle Snake. In addition, Congress has appropriated $4 million to the Forest Service for land acquisition from private holdings in the Middle Snake reach.

The issue is clear – preservation of an outstanding river canyon in its natural state versus inundation of it, or portions of it, with reservoirs constructed primarily to produce hydroelectric power. It is doubtful that information additional to that now available would be helpful to the Congress in deciding this basic issue. Congress should act promptly in resolving this issue so that firm plans for the future use of this important river can proceed.

Erosion of the Palouse Region. – For more than half a century, water, wind, and improper tillage have stripped irreplacable top soil from cultivated grain lands in the 8.4 million acre Palouse area centered in 25 counties in eastern Washington, northwestern Idaho, and northeastern Oregon. Here soil is wasted by erosion at one of the highest rates anywhere in the United States. As a result of this erosion dust pollutes the air as much as 100 miles downwind from the eroding fields creating severe traffic hazards. Soil washed from eroding fields ends up as sediment in highway drainage ditches, ponds, reservoirs, and streams. Once clear mountain-fed streams have become polluted and unfit for human consumption, industry, recreation, and for use by fish and wildlife.

The Palouse is blessed with an ideal climate and soil for production of grain and continues to be one of the Nation's most productive agricultural regions. It averages an annual output of more than 120 million bushels of wheat, produces 80 percent of the Nation's bluegrass seed, most of its lentils, and large quantities of barley and dry peas.

In virgin condition under perennial grass cover the soil resisted erosion quite well. It had a deep moisture storing profile, and the surface soil absorbed water readily because of the high content of organic material. In 70 years of cultivation about half of the original organic matter and much of the soil structure have seriously deteriorated on lands subject to erosion.

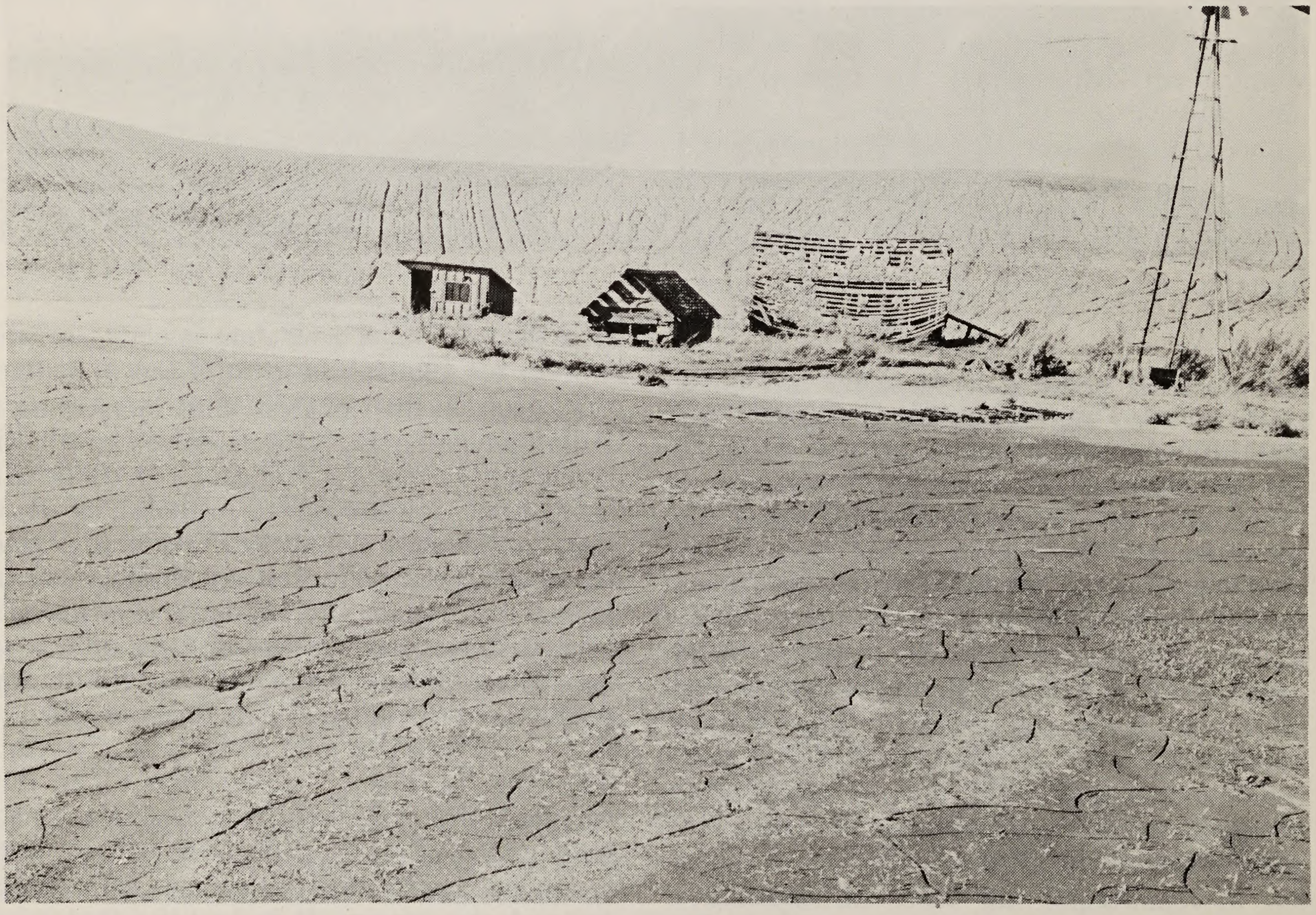


Figure 24. Erosion and cracked mud sediment, Palouse area, Washington.

Detailed soil surveys in the Palouse area indicate that all of the original topsoil has been eroded from about 10 percent of the land and that from one-fourth to three-fourths of the original soil has been removed from an additional 60 percent of the cultivated area. Continued erosion will seriously damage the remaining productive capacity of the land.

Not only is the eroding land base a serious problem but the eroded silt and sediment create further serious problems. The Corps of Engineers, for instance, has modified or deferred plans for 24 of 27 water-based recreation sites along the lower Snake River in connection with the multiple-purpose dams being built there because of the heavy sediment load entering the Snake River. In Whitman County alone, $400,000 is budgeted annually to remove silt from the county road system. There are about 16,500 miles of roads in the Palouse area of which 5,000 to 6,000 miles are subject to damage by erosion and sedimentation.

Paradoxically, crop yields in the Palouse have been increasing in the face of a deteriorating land base. These increases, however, have been due solely to improved technology including better seeds, better fertilizers, and more efficient production techniques. They have more than offset reductions in yields because of land resource deterioration. This trend cannot continue indefinitely and, with continued erosion and loss of the land base, must reverse at some future time.

Wheat has long been the most profitable crop produced in the Palouse region nonirrigated area. Total income, as well as income per man hour invested by the farmer, is highest from wheat. Therefore, the wheat allotment program which restricted wheat acreage has had a powerful influence on income, on land values, on cropping systems, and on land treatment.

The original allotment was based on "wheat history" and this rewarded the farmer who had been raising wheat on the highest percentage of his total acres, regardless of the suitability of such land for wheat production. On the other hand, farmers who at the time allotments were set had less land in wheat because they had planted grass on erosion-vulnerable fields received a lower wheat allotment and this led to reduced income.

This condition ultimately affected land values, and a farm with the highest "wheat base" sold for the most money regardless of the actual productive capacity of the soil since "wheat base" could be transferred from one piece of land to another under a single farm operation.

In spite of the fact that most of these inequities have been corrected by adjustment of "wheat base," by instituting a "bushel control" in addition to "acre control" and by other means, the fear of losing allotment history by having part of the farm in grass at the time the base is established still exists in the minds of most farmers. It is a powerful force dissuading the planting of grass or trees on erosion-vulnerable lands. These and other reasons, such as the basic economic incentives of wheat farming, can be set forth to explain why past efforts at controlling erosion have not been successful in the Palouse.

Solution of the erosion problems of the Palouse region must involve a long-range program of effective erosion control and sediment reduction by land and water management practices. Application of balanced livestock – grass-grain production enterprises would do much toward securing proper land use on the most hazardous areas.

While many land owners have carried out effective erosion control practices much more remains to be accomplished. More information and educational efforts are needed to highlight the consequences of land quality depletion and of sediment effects on water quality over time and the advantages of a grass-livestock alternative in highly eroding areas. The national interest in meeting future food requirements implies a national importance to a strong, aggressive program to preserve the great productive capacity of the Palouse region.

Anadromous Fisheries in the Northwest. – The rivers of the Pacific Northwest historically have been the seed bed for the major part of the vast multitudes of anadromous Pacific salmon and trout. As man moved into the Northwest, particularly the Columbia River basin, his activities led to loss of spawning habitat, construction of dams, and other impediments to upstream and downstream migrations, deterioration of water quality, adverse changes in streamflow patterns, and high fishing pressures. These have all led to a deterioration of the anadromous fishery. It has been estimated that the Columbia River system once yielded about 50 million pounds of fish annually, but commercial fish catches declined from 1911 to 1960 approximately one-half of this amount.

A major contributor to the decline in fish stocks was the development of water control and diversion facilities on the rivers. Portions of important tributary streams such as the main stem of the Columbia River include fish passage facilities, but these cause delays in migration timing and fish losses. Important habitat once used by spawning fish was inundated and extensive sections of streams were dewatered by diversions during critical seasons of the year. Water temperature changes, introduction of dissolved gasses and other toxic substances, and increased loads of silt and wastes also contributed to the decline.

The period 1960 to 1971 shows a slight reversal of the trend. Stocks of fish and sport and commercial landings slightly increased during this period. This reversal can be attributed to the fish conservation and protection measures that were applied. These measures include the construction of additional fish passage devices at existing structures and natural barriers, improved fish handling facilities, installation of screens at diversion dams, improved operating procedures that decreased physical

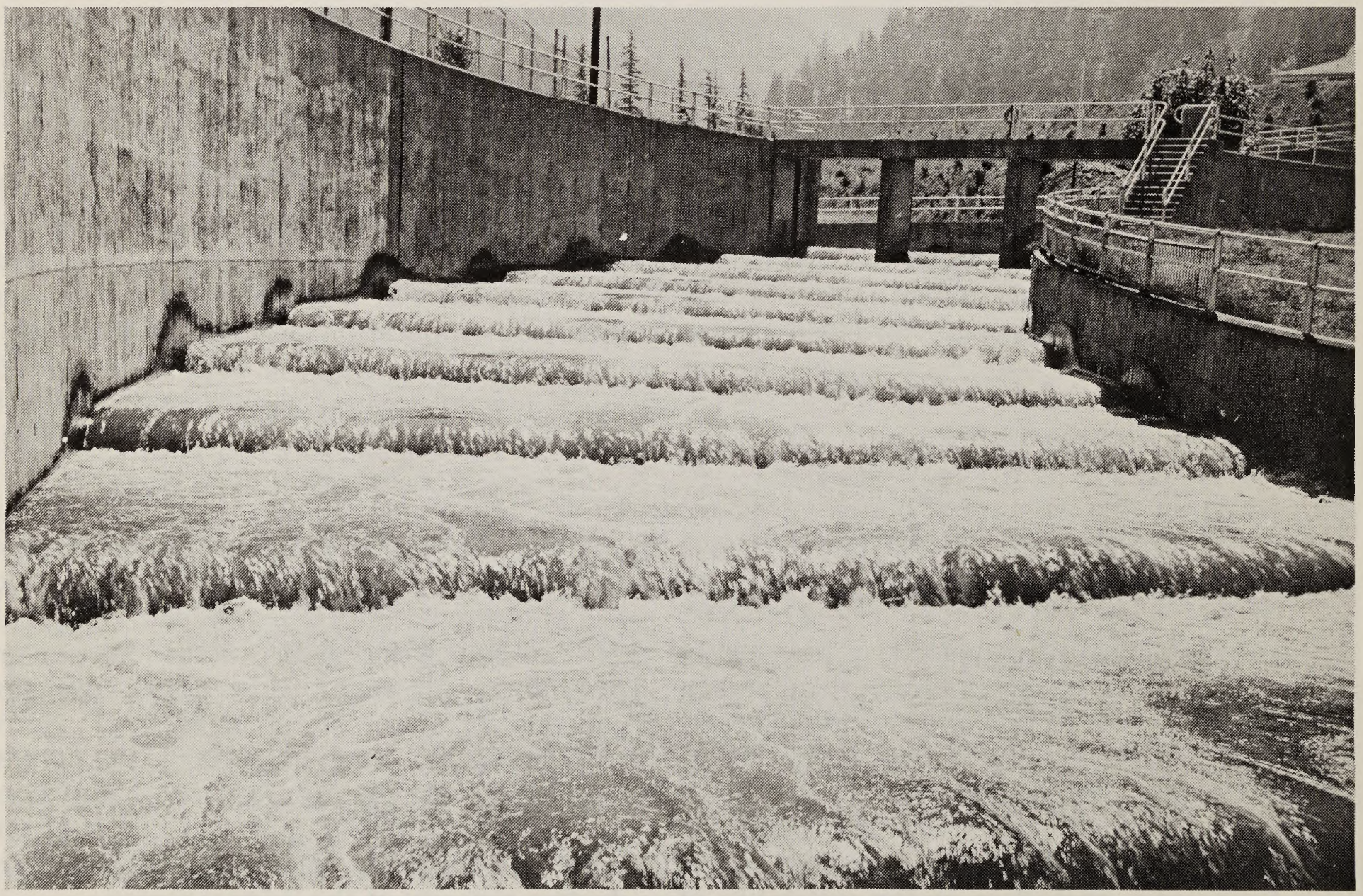


Figure 25. Fish ladder on Columbia River Dam.

injury and limited supersaturation of dissolved gasses, development or improvement of spawning habitat, and the operation of an extensive artificial propagation program. Practical research programs conducted by State and Federal agencies, coupled with the cooperative efforts of public and private agencies responsible for operation of water control facilities, contributed to the successful effort.

Potential measures, however, to meet needs for energy production, water supply, food and fibre production, and navigation may further impair fish habitat and migration. These potential measures include modification of the low head dams on the Columbia and Snake Rivers to increase both baseload energy production and peaking power capacity, installation of new conventional and pumped-storage hydroelectric plants, and construction of steam-electric plants powered by nuclear energy with attendant waste heat disposal effects. Increased diversions for municipal and industrial water supply, particularly in the Puget Sound area, and for agricultural uses may further deplete productive habitat.

Protection and enhancement of the anadromous fishery resources of the Northwest are of vital importance to the region and the rest of the Nation. Additional effort is needed to provide an anadromous fish protection and enhancement plant that assures continued production of this important food and recreation resource. The plan should be comprehensive in that it is covering all important spawning, rearing, and fish passage areas necessary to sustain production. Such a plan would not only assist in the conservation and development of anadromous fish resources but would aid in balancing this use of northwest streams with other existing and proposed uses.

STATE PROBLEMS

The individual states were selected as the basic geographic areas of analysis for defining water and related resource problems. Federal-State study teams were organized for each State and it was essentially through this means that the critical problems for each State were identified and defined. The problems heretofore discussed as Westwide Problems are found to some extent in each State. They are not, therefore, either in the Main Report or in this Executive Summary reviewed under the heading of State Problems unless special attention is warranted. The same is true in respect to Regional Problems.

Each State has a number of water and related land resource problems that are unique to it. Only the more critical have been selected for treatment in this report. Even so, to adequately discuss these problems in an Executive Summary report would unduly lengthen and overburden it. Therefore, the presentation of these problems in this Executive Summary will cover little more than their identification. The reader is referred to the Report for a detailed State-by-State presentation of critical State problems.

Arizona

Arizona has about 1,800,000 people, 75 percent of whom are concentrated in the metropolitan centers of Phoenix and Tucson. The desirable southwest climate, abundant recreation, and scenic attractions, and the strong retirement appeal of the land have led to a tremendous surge in population expansion and in commercial and industrial development since World War II. In the past generation, the State has undergone a transition from basically a mining and agricultural economy to one much more diversified. Today, the leading sources of income are manufacturing, mining, agriculture, and tourism. Forty-nine percent of Arizona is in Federal ownership. Another 27 percent is in Indian Trust lands. Arizona is a water-short state whose current water use far exceeds its available long-term supply. A large portion of today's uses is being met by the mining of ground water. The more critical water and related resources problems of Arizona, other than those discussed under Westwide and Regional Problems are as follows:

Municipal Water Supply. – In Northern Arizona there are 15 small communities with a total population of 51,000 that have critical water problems. The problems appear about equally divided between those of quality and quantity. Remedial measures, in most cases, will be costly.

Water Supply in the Lower Salt-Gila River Basin Area. – The growth of irrigated agriculture in the Central Arizona area, particularly since World War II, has led to an increasingly serious ground-water overdraft situation. The growing population and rapidly expanding manufacturing industries also have contributed to the problem. At present, the rate of overdraft is estimated at 2.5 million acre-feet per year. Ground-water levels are at an average of 250 feet below the surface and declining steadily. The Central Arizona project, now under construction, will for several decades import an average of 1.2 million acre-feet of water annually into the area and thus relieve the overdraft to some extent.

Taking into account the present ground-water overdraft of 2.5 million acre-feet in the central Arizona area, together with constantly increasing demands for water, it is evident that the central Arizona area will continue to face the situation where water demands are greater than long-term water supplies. The only way such full demands could be met is by importing additional water into the area. Inasmuch as the water supply available is far in excess of forseeable demands for municipal and industrial purposes, the justification for such additional imports would have to rely on the value of water for irrigation even though this may require some changes in Arizona water law to effect transfers of water rights. It is

Figure 26. Heart of Phoenix, Arizona.

doubtful if such justification can be demonstrated in the foreseeable future. Thus, it appears that the future of the central Arizona area, insofar as water supply is concerned, should be planned on the basis of present water supplies enhanced by whatever additional conservation practices are feasible, possible augmentation of the Salt and Gila Rivers by weather modification, plus the potential imports from the Central Arizona project.

Water for Energy Production. – Large thermal plants are expected to meet the bulk of future in-state electricity demands which are rising rapidly in the Phoenix metropolitan area. By 2000, some 22,600 megawatts of additional capacity are projected as required to meet needs. Associated water demands are estimated to be 274,000 acre-feet per year of which 224,000 acre-feet could possibly come from irrigation drainage water and municipal return flows. These thermal power water requirements will constitute one more demand for water in a critically water-short area. With rapid growth in central Arizona, the recycling of sewage effluent for power generation is destined to become and important practice.

Water for Indian Reservations. – There are 19 Indian reservations in Arizona totalling nearly 20 million acres or 27 percent of the State. The Indian population in 1970 was 114,000. Under court decreed water rights, Indian reservations along the lower Colorado main stem have secured water allocations sufficient to fully develop their irrigation potential. This irrigation hopefully will occur in the near time frame.

The Indian tribes residing in the Central Arizona project service area will receive significant new water supplies from the Central Arizona project although the exact quantities have not yet been determined. The Fort

McDowell and Salt River Indian Tribes also will receive substantial benefits other than water supply from construction of the Central Arizona project.

Accelerated programs are needed to permit the Indians to use the water supplies available from the lower Colorado River. Also, plans should be advanced as soon as practical for the Indians' use of their share of Central Arizona project water. Water requirements for other reservations should be determined.

Chronic Flooding in Developed Areas of the State. – Although Arizona is one of the most arid areas in the Nation, it has been constantly plagued by damaging floods. These are caused by general low-intensity winter storms of long duration, by general high-intensity summer storms over wide areas, and by local thunderstorms. Many proposed and authorized remedial projects have been delayed because local entities did not have sufficient resources to fulfill local obligations required under Federal programs. To resolve the delay of construction, the Arizona Water Commission prepared a consolidated 15-year program of 47 projects which would provide needed flood control. Of those selected, 25 have been planned by the Soil Conservation Service, 19 by the Corps, and 3 by the Bureau of Reclamation. Total estimated costs, as of 1972, were $390 million, of which $77 million were local costs. In the 1973 legislative session, the State authorized $64 million in assistance to local entities for these flood control projects. This should remove the primary obstacle of the past in advancing flood control programs. As local assurances are provided, the Federal agencies should seek funds to move their programs as expeditiously as practical.

Insufficient Water Supplies for Anticipated Outlying Urban Growth. – Several northern Arizona communities' population growth and economic expansion are taxing limited water supplies. The conditions have been magnified through national promotion by land developer and land speculation operations offering land in "Sun Country."

Such land is often adjacent to small rural communities and not included in existing water service systems. Settlement on these hitherto desert lands would create an immediate crisis to the local community and would generate consumptive uses of water in some instances that would infringe on downstream water rights. These past uncontrolled land speculation schemes led to passage of an Arizona ground water law in 1973 which required a determination of available water supply, or lack thereof, for such land development by the Arizona Water Commission. Strict application of this law should be made.

California

California is the most populous state as a result of one of the fastest growth periods ever experienced, moving from less than 7 million people in 1940 to nearly 20 million in 1970. California's population is highly urbanized with more than 90 percent living in the large coastal urban areas. Since World War II, the State has shifted from a rural-agrarian to an industrial base with the emphasis on agribusiness and aerospace industries. With 1970 production valued at $4 billion, California has been the leading agricultural state for more than 20 years. Forty-four percent of California is in Federal ownership. California's surface water supplies of over 70 million acre-feet are ample to meet its water requirements far into the future. However, areas of water surpluses are in the northern part of the State while areas of primary water demand are in the central and southern portions. This has led to the long water transport facilities that characterize California's water supply system. The more critical water and related resources problems of California, other than those discussed under Westwide and Regional Problems, are as follows:

Municipal Water Supply for Small Communities. – There are 34 communities in California with a total population of 89,600 which have applied for water supply assistance. Ground-water overdraft, land subsidence, water quality and inadequate distribution systems are the most prevalent problems.

American River Flows. – Flow regulation provided by a Federal project – pending Auburn Dam – has been ordered by an agency of the State. Such regulation, without additional facilities or actions, would prevent fulfillment of authorized purposes of the Auburn-Folsom South unit. Hence a Federal vs. State jurisdiction issue has arisen which is now in the courts. There are several alternative plans by which both the State decreed flows and the authorized Auburn-Folsom South unit can be accommodated. Implementation of such plans will require additional authorization and additional expenditures.

Delta Environmental Quality. – The increased diversion of Sacramento-San Joaquin River flows from the delta to southern areas of the state will result in increased duration of present salinity levels occurring during summer months. This may cause increased physiological stress to fish and fish food organisms resulting in their displacement upriver or reduced survival. The existing level of diversion results in flow reversals within delta channels which may displace fish eggs and larvae and young fish to areas where the environment may be more hostile to their survival. A near-term solution is needed for the establishment of adequate levels and location of outflow from the two stream systems to stabilize the ecological system of the delta and maintain the valuable delta fishery.

From 1961-65, an Interagency Delta Committee investigated alternative solutions to

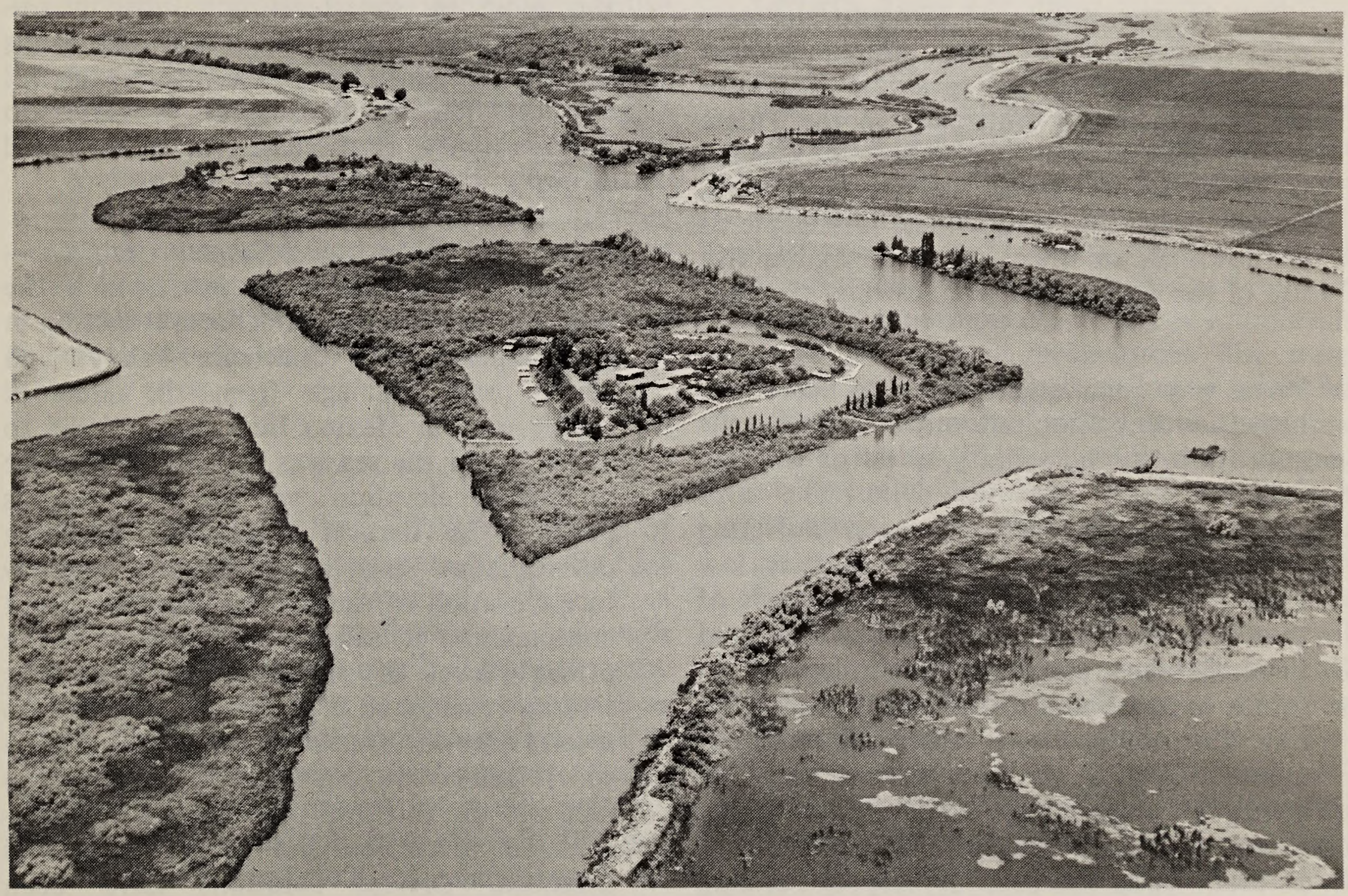


Figure 27. Typical Sacramento-San Joaquin delta landscape, California.

problems caused by cross-delta water conveyance such as hydraulic barriers, physical barriers, and delta waterway control plans. The Team, in 1965, selected as the optimum solution a 43-mile-long 21,800-ft^3/s "Peripheral Canal" around the eastern edge of the delta connecting the Sacramento River directly to the export pumps in the southern delta. This plan is strongly endorsed by water development agencies as the solution to the delta environmental quality problem. It is conditionally endorsed by fish and wildlife management agencies, some environmental groups, and some local counties pending clarification of operational criteria for the unit; and unconditionally opposed by other interests.

Water Supply, Drainage, and Water Quality Problems in the San Joaquin Basin. – Seasonal shortages due to the natural variations in runoff are experienced in the upper San Joaquin basin which are presently being offset by the mining of ground-water supplies to the extent of over 1 million acre-feet per year. This is causing severe land subsidence problems, principally in the Tulare region. The ground-water supply is expected to be at critical levels by the mid-1980's. Present legal and institutional arrangements do not facilitate the coordinated conjunctive use of the surface and ground-water systems.

Waste water and irrigation return flows with high concentration of nitrates and salts contribute to the salinity levels of the San Joaquin River and the delta. The river system and delta are presently suffering from high levels of nutrient pollution, low dissolved oxygen levels, and high levels of total dissolved solids. Original State and Federal plans included the collection of return drainage and disposition in the delta, but this could result in adverse environmental effects in the delta without adequate management practices. To date, no widely accepted plan for collection and disposition of drain water has been developed. Ponding of saline return flow is being practiced as a temporary measure and has resulted in the establishment of a substantial wildlife habitat.

Decline of Anadromous Fishery in the Eel and Trinity Rivers. – Anadromous fish runs of salmon and steelhead populations have been declining in several North Coast rivers and streams, including the Eel and Trinity Rivers. Since construction of the Trinity project and transbasin diversion of flows to the Sacramento River, there has been a drastic decline of steelhead runs in the Trinity River. An understanding of the causes of these declines and an action program which will aid in restoring anadromous fish runs are critical to consideration of further storage regulation and diversion in northwest California.

Impact of Colorado River Salinity on California Users. – California is by far the largest user of water from the lower Colorado River and stands to be damaged the most by deteriorating salinity conditions. On the other hand, California stands to gain the most from measures to control salinity. The entire subject of Colorado River salinity is discussed as a Regional Issue.

Salton Sea Fishery and Salinity Conflict. – Salton Sea is the sump into which the drainage and seepage water from irrigation in the Imperial and Coachella Valleys and wastes and drainage from the Mexicali Valley area in Mexico flow. From 1925 to 1964, when the sea was expanding, the rise in surface elevation was the most serious problem in that it threatened shoreline development. Since 1964, however, the surface elevation of the sea has been stable and consequently its salinity has increased to the present level of 38,000 p/m. When the salinity reaches 40,000 p/m in about 4 years severe adverse effects on the sea's valuable sport fishery are expected. Ultimately the fish will die out and other forms of water-oriented recreation and wildlife uses will diminish. Several solutions have been defined, all of which are costly. Decision is needed as to whether a program to preserve the recreation and fish and wildlife uses of Salton Sea is feasible and justified and, if so, to what extent the Federal Government should participate.

Water for Energy Demands. – Most of the electricity in California today is generated and used in the coastal areas. Since World War II, the majority of new powerplants has been fueled by gas and oil and located on large bodies of water, such as bays, estuaries, and the Pacific Ocean, which provide the large quantities of once-through cooling water required.

The bulk of future power generation is expected to be by nuclear-fired thermal plants. Because of environmental, safety, and aesthetic considerations, it is expected that these future plants will be on inland sites.

Sites for inland plants are much more plentiful and are in less seismically active areas. Most of the favorable areas for nuclear powerplant sites are in the Central Valley and the southeastern desert area. Siting in these areas would likely require evaporative cooling. If all new nuclear powerplants needed over the next 20 years were located inland and used freshwater for evaporative cooling, approximately 1 million acre-feet of water annually would be needed. This will create competitive water use situations in some areas.

Colorado

Colorado has more than 2,200,000 people of whom 80 percent are concentrated on the East Slope of the Rocky Mountains from Fort Collins on the north to Pueblo on the south and centering in the Denver metropolitan area. Colorado is faced with explosive urbanization along the Front Range compared with lack of growth in neighboring rural regions. Manufacturing is the foremost economic activity, followed by agriculture and tourism. Oil, gas, and coal are produced in quantity and the potential for major increases is large. Thirty-five percent of Colorado is in Federal ownership. Colorado is at the headwater of four major river systems, the Missouri, Arkansas, Rio Grande, and Colorado. In the Rio Grande basin, Colorado is using its entire Compact allotment. In the Arkansas and Missouri basins, it is using 86 and 91 percent of its total supply. In the Colorado River basin, it is using about one-half of its assured Compact entitlement, but practically all of the rest is committed to use. The more critical water and related resource problems of Colorado, other than those discussed under Westwide and Regional Problems, are as follows:

Municipal Water Supply. – Quality problems seriously affect 14 communities in the Arkansas River basin, 23 communities in the South Platte basin, and 4 communities in the upper Colorado region. Also, three communities in the upper Colorado region are in short supply.

Water Supply for Population and Economic Growth Along the Front Range. – Population increases are creating water supply and water oriented recreation problems along Colorado's Front Range. Water demands are currently being met from local surface and ground water resources, conversion of agricultural water rights to municipal and industrial needs, and transregional diversions. Future demands are expected to be met through expansion of the above sources and some waste-water reclamation. The water supply problem at this time is not associated with running out of water in the near time frame. Rather, the concern is over increasing transregional diversions, regulatory storage, pumping ground water, and converting irrigation water right uses for prime agricultural land to municipal and industrial purposes. Diversion of additional West Slope water will be complex and costly and will be challenged by environmental groups and West Slope interests.

The meeting of water-oriented recreation demands in the Front Range area is a continuous and increasing problem. Flat-water recreation opportunities are being provided, although not adequately, by a

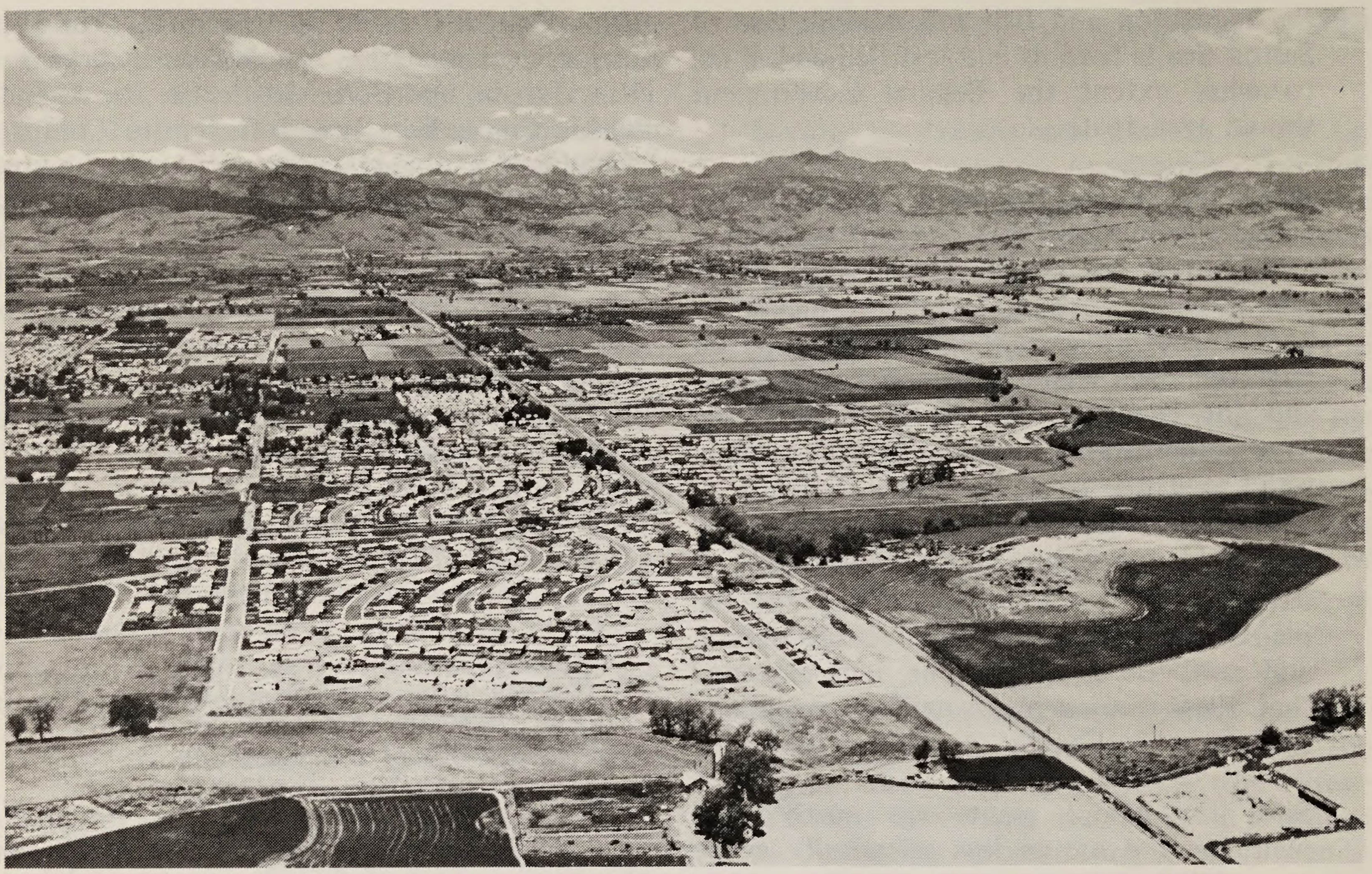


Figure 28. ***Subdivision of farmlands along front range, Colorado.***

number of irrigation and water supply reservoirs situated between Fort Collins and Pueblo and on the West Slope within a day's commuting distance. All bodies of water, both public and private of which there are more than 400 of over 3 acres in size within 20 miles of Denver, should, to the extent practicable, be made available for recreation use.

Water for Energy Resource Development. – Colorado has extensive reserves of coal and oil shale in the upper Colorado basin. Although current development of these resources is not significant their future exploitation is expected to take on major proportions. Accompanying this will be substantial water demands for mining, processing, and related municipal requirements. These demands will compete with other uses for a limited water supply. Development of these resources will involve environmental considerations. It is expected also that thermal power generation along the Front Range will expand significantly. Water to support this expansion, in all probability, will come from increased transregional diversions or from conversion of agricultural water to industrial purposes. The basic problem to which the State and other concerns should address themselves is the most appropriate allocation of a limited water supply.

Land and Water Resource Problems of the Arkansas River Valley. – The Arkansas River Valley is experiencing most of the problems associated with growth occurring in an area of limited water supply. The demand for municipal and industrial water is growing rapidly and is being met from conversion of water from agricultural use, which adversely affects a basic economic activity of the region. In the upper Arkansas mine wastes have contributed to pollution of water supplies. Floods are an ever-present threat and erosion and sediment problems are serious. Operation criteria for John Martin Reservoir severely limit the usefulness of the reservoir for recreational use. A coordinated long-range land and water-use plan for the region is needed.

Salinity Impacts. – Within Colorado, the adverse affects of salinity are evidenced primarily on the South Platte and Arkansas River. From north of Denver to the Nebraska-Colorado State line, the South Platte River salinity increases from 516 to 1,330 p/m. The Arkansas River salinity increases from 365 p/m near Pueblo to 2,200 p/m near the Colorado-Kansas State line. Increased salinity levels are adversely affecting the municipal supplies for several communities. Production from irrigated areas is affected and, with increasing salinity, will be seriously affected. Measures to control salinity increases are needed.

In the Colorado River basin, salinity concentrations are not a serious problem within Colorado. However, return flows from Grand Valley and other irrigated areas and salts added by natural sources such as from Paradox Valley contribute significantly to the salinity problems of the lower Colorado region. Much can and should be done in Colorado to prevent further deterioration of lower Colorado River water quality.

Idaho

Idaho has about 770,000 people concentrated mostly in the southern portion of the State. Like several other Western States, it is a land of contrast – rugged mountains and wild rivers but also peaceful streams and valleys, vast forests, and sage-covered deserts. Agriculture is its primary industry, followed by forest products, manufacturing, tourism, and mining. Irrigated agriculture is the base for growing business activity associated with the processing of food and livestock products. Sixty-one percent of Idaho is in Federal ownership. Idaho has huge amounts of water, but the critical area for consumptive use purposes is the Snake River above Milner Dam. The flows of Snake River above that point are almost entirely appropriated and diverted and shortages occur in dry years. The more critical water-related resource problems in Idaho, other than those discussed under Westwide and Regional Problem, are as follows.

Need to Determine Instream Flow Requirements. – Due to extensive diversions and consumptive uses, the flow of water in many of Idaho's streams, including many in the Snake River basin, is not now believed sufficient to meet the needs of instream uses, primarily for fish and wildlife, recreation, aesthetics, and general water quality. Fourteen stream reaches on various rivers within the State have been identified as having a high study priority for determination of instream needs. Before instream flow requirements can be established, more information needs to be compiled on the amount of water needed to support various instream uses.

Competing Uses of Water and Land Resources in the Boise and Payette River Basins. – The Boise-Payette River basin complex has a number of interrelated water and land-use problems that include: need for modernization of the municipal water system for Boise, loss of prime agricultural land to urban expansion, inadequate recreation facilities at several Federal reservoirs, serious water quality problems along the lower Boise River, localized drainage problems, undeveloped hydroelectric power potentials, fish and wildlife enhancement, and flood damage reduction. A comprehensive total water management type study is needed.

Water for Energy Resource Development. – Idaho still has a significant amount of undeveloped hydroelectric potential. Many of the potentials, however, would involve intensive environmental conflicts. There are potentials that need to be studied for increasing generating capacity at some existing powerplants. Although Idaho has no known reserves of fossil fuels large enough to supply the requirements of economically sized thermal generating units, its abundant water supplies, along with high voltage transmission, might make it attractive as a center for thermal generation with coal transported in from Wyoming or Montana or for nuclear-fired plants. Both the hydroelectric and thermal potentials warrant further analysis.

Competing Uses for Water and Land Resources of the Upper Snake River Basin. – A group of problems exist in the upper Snake basin including: adverse water quality conditions in Milner Reservoir and the lower Portneuf River; flood problems in several spot areas along Sand Creek, Willow Creek, Portneuf River, Lower Blackfoot River, Lava Hot Springs area, Big Lost River, and Snake River; stabilization of Jackson Lake; deteriorating conditions at American Falls Dam; supplemental irrigation water in the Raft River, Oakley Fan, and Salmon Falls areas; need for measures to protect recreational values in prime recreational areas such as Henrys Lake, Island Park Reservoir, the Big Springs area, Palisades Reservoir, and the Wood River basin; erosion and sedimentation in the Twin Falls-Rupert area, east of Lake Walcott, and in the Rockland and Arbon Valleys; preservation and enhancement of Thousand Springs, Shoshone Falls, and Twin Falls; restoration of Grays Lake; development of resources of the Fort Hall Indian Reservation; and general enhancement of fish and wildlife habitat. The variety of problems and their complexity call for greater and more comprehensive basin analysis than can be accomplished under present funding levels.

Federal Assistance for Irrigation. – Idaho has well in excess of 1 million acres of potentially irrigable new land for which adequate water supplies are available. It is important, therefore, to future planning for the State that policy as to future Federal assistance to irrigation development be determined promptly.

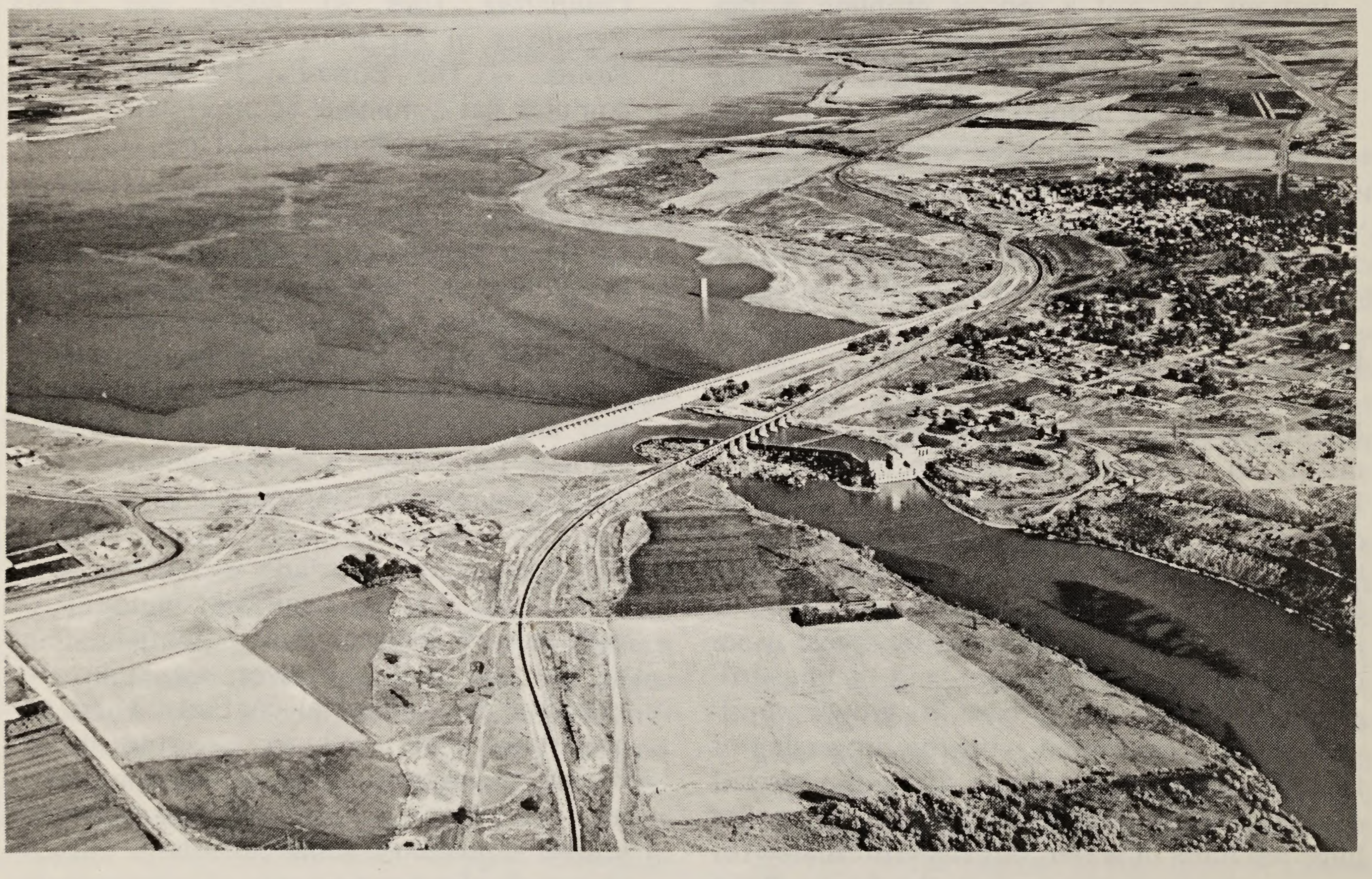


Figure 29. American Falls Dam, Idaho, soon to be replaced.

Montana

Montana has 694,000 people. It has wide open spaces, mountains, and some of the most beautiful scenery in the Nation. It has large areas suitable for cultivation and for fine native pasture. It has timber and extensive mineral-rich deposits, including low-sulphur coal. Twenty-nine percent of Montana is federally owned. Both in the Columbia and Missouri River drainages, Montana is well endowed with water. There appears to be ample water supply to meet foreseeable needs. Its more critical water and related land-resource problems other than those discussed under Westwide and Regional Problems, are as follows:

Municipal Water Supply. – Montana has one of the most critical small community water supply problems in the Westwide area. There are 110 communities with a total population of 105,000 that need additional or improved water supplies and facilities.

Environmental Data Gap. – Concern for the natural environment runs high in Montana. Potential conflicts between developmental and preservation interests call for special efforts to make sure that adequate background data on environmental values are available to guide future State decisions, particularly as related to coal development.

Water for Energy Resource Development. – The coal fields of eastern Montana have national significance in terms of meeting national energy needs. If devoted to meeting national needs, related water demands could eventually amount to several hundred thousand acre-feet annually, requiring extensive interbasin water conveyance systems to carry available water from the Yellowstone-Missouri River systems to the coal fields. Sensitive environmental issues would be involved as well as Indian impacts.

Water Quality in the Yellowstone and Missouri River Basins. – The Yellowstone and Missouri basins have a critical water quality problem due to erosion, sedimentation, agricultural wastes, mining, and municipal and industrial discharges. At least 25 communities and industries are not in compliance with State water quality standards. Salt loads from natural, irrigation, and some mining sources are high.

Erosion and Sedimentation on Muddy Creek and Sun River. – Channel degradation and excessive erosion of Muddy Creek caused by irrigation return flows and wastes from the Federal Sun River Irrigation project and private irrigation development have caused severe erosion and sedimentation problems on lower Muddy Creek and the Sun River.

Conflicts in Proposed Flathead River Basin Resource Uses. – The Flathead River basin has great potentials for water resources development that would clash head on with existing environmental values. It has outstanding potentials for hydroelectric development. It has potentials for irrigation expansion. It has severe flood problems. Unfortunately, reservoir storage to realize these potentials and to solve flood problems would impinge on important national parks or wilderness areas. The fishery and big game values of the basin are among the finest in the Nation. There are important wild and scenic river potentials as well as important recreation potentials. The Flathead Indian Reservation has an important stake in the future course of resource conservation and development in the basin. All of these potentials and interests call for formulation of a comprehensive plan, not now available, for long-range conservation and development of the basin's resources.

Saline Seeps. – Saline seeps are usually low lying or closed basin lands where, because of natural geologic conditions aggravated by agricultural practices, salts and emerging to the surface and destroying productive agricultural land. Recent estimates of the area of cropland in Montana, where production has either been eliminated or significantly reduced, range from 150,000 to 200,000 acres. The annual increase in occurrence of these areas is about 10 percent. There is a total area in Montana of 16,500 square miles

*Figure 30. **Flathead Lake, Montana.***

or over 10 million acres within which saline seeps may develop.

Nevada

Nevada, with a population of nearly one-half million, is undergoing one of the fastest growing rates in the Nation. Its population is centered in two principal metropolitan areas – Las Vegas and the Reno-Sparks-Lake Tahoe area. Recreation and tourism are the catalysts to the economic growth of these urban centers. The livestock industry is the major support for the State's rural economy. Eight-six percent of Nevada is in Federal ownership. Due to its mountain barriers, precipitation for Nevada is less than for any other Western State. All of its principal drainages flow inland and do not reach the sea. Major areas of Nevada are already in water-short status and further shortages are on the horizon. Its more critical water and related land resource problems, other than those discussed under Westwide and Regional Problems, are as follows:

Municipal Water Supply. – Some 28 communities with a total population of 24,000 located mostly in the closed basin areas in the center of the State, need additional or improved water supplies and facilities. Several systems developed during the mining period of the late 1800's and early 1900's should be replaced completely.

Environmental Data Gap. – Nevada has seven threatened fish species which are peculiarly adapted to its desert region – the Lahontan cutthroat trout, cui-ui, Pahronagat bonytail, Moapa dace, Devil's Hole pupfish, Warm Springs pupfish, and the Pahrump killifish. Research on habitat requirements of these endangered species should be accelerated so that adequate consideration of those requirements can be given in water planning.

Colorado River Water Supply. – Nevada's use of water from the Colorado River is almost entirely for the Las Vegas-Clark County area. Its 1975 projected use is 107,000 acre-feet out of Nevada's basic annual Colorado River allotment of 300,000 acre-feet. This basin allotment is expected to meet Las Vegas-Clark County area needs until at least 1990.

Conflict of Water Allocation and Use in the Carson-Truckee River Basins. – Within the Carson-Truckee River basins, a full spectrum of interrelated water problems exist, involving agricultural and municipal supply, stream pollution, flooding, terminal lake maintenance, recreation, fish and wildlife needs, Indian needs, State-Federal water rights, and inter-State division of waters. The basic problem is that the natural water supply of the two basins is not adequate to meet all of the present demands. As a result, diversions are such that the level of Pyramid Lake, the terminus of Truckee River and an important resource of the Paiute Indian Tribe, is continually receding with adverse effects on the Indians. The rights of the Indians to a greater share of Truckee River water are now in litigation. Court decisions could well affect the extent of water supplies available to Pyramid Lake, the Truckee-Carson Irrigation District, the Stillwater Wildlife Refuge, municipal water supplies for the Reno-Sparks area and other basin uses.

Pollution of Las Vegas Arm of Lake Mead. – For many years municipal and industrial wastes from the Las Vegas Valley have been discharged into Las Vegas Wash, polluting Lake Mead and the Colorado River. The problem is under enforcement action of the Environmental Protection Agency. Several remedial plans have been proposed but none as yet accepted by the Nevada Legislature.

Water for Indian Reservations. – There are 21 Indian reservations covering about 1.3 million acres in Nevada. The problems of declining lake levels (Pyramid and Walker Lakes), increases in lake salinity, and severe competiton for available water supplies in widespread areas of the state are predominant.

Need for Regulation of Humboldt River. – Practically the entire area along the Humboldt River and its lower tributaries is subject to damage from floods. At the same time the 343,000 acres of irrigated land in the Humboldt basin suffers from lack of an adequately regulated water supply. A regulated streamflow would also enhance the existing fishery. Construction of authorized upstream reservoirs plus their coordinated operation with existing structures under a total water management plan could do much to resolve the basin's problems.

Decline of Walker Lake. – As upstream uses increase, Walker Lake, the terminus of Walker River, is receding with consequent increases in salinity and threat to the freshwater fishery of the lake. Alternative plans have been proposed which would (1) maintain Walker Lake at its present level through net decreases in upstream uses or (2) expand upstream uses for irrigation mining, recreation and fish and wildlife at the expense of further declines in the level of Walker Lake. More study and information are needed to facilitate reaching a decision as to which alternative should be followed.

Water for Energy Resource Development. – Several remote southern Nevada desert valleys appear to have site potentials for either coal or nuclear fuel powerplants. Sufficient ground water is available so that if mined over the lifetime of the powerplant it could meet cooling water requirements. Powerplants here would require importation of fuel from other states.

Figure 31. ***Pyramid Lake, Nevada.***

New Mexico

Slightly more than 1 million people reside in New Mexico, one-third of whom are in the Albuquerque metropolitan area. New Mexico is rich in natural resources. Minerals, including coal, natural gas, petroleum, copper, and uranium, comprise one of the State's major economic attractions. Lumbering and processing of wood products rank high. Tourism is the most rapidly growing enterprise. Agriculture, including grazing and irrigated agriculture, is important but industrial and municipal water demands are making inroads on existing irrigation. Thirty-four percent of the State is in Federal ownership. New Mexico is already a water-deficient area. Practically the entire surface water supply of the State is being used beneficially or is committed to use within the terms of international treaties, interstate compacts, court decrees, and State laws. Its more critical water and related land resource problems, other than those discussed under Westwide and Regional Problems, are as follows:

Municipal Water Supply. – There are about 180 communities in New Mexico having populations of less than 2,500 that do not have public water facilities. Approximately 28 percent of the State's population is not served by public water facilities. At least 36 communities need improvements to their present systems. Major problems are: encroachment of saline water in the southern part of the Pecos River basin, declining ground water in the High Plains area, and excess mineralization of supplies.

Erosion and Sedimentation. – New Mexico has the highest rate of soil erosion of all the 11 Western States. It averages 0.54 acre-foot per square mile compared with 0.30 acre-foot for the entire Westwide area. Excessive erosion and sedimentation are problems in the Rio Grande and Pecos Rivers and in connection with coal development in northwest New Mexico.

Colorado River Water Supply. – New Mexico's share of the upper basin's assured Compact allotment of Colorado River water is completely committed to existing, authorized and proposed uses approved by the State.

Declining Ground Water in Eastern New Mexico. – The thriving economy of the eastern New Mexico-west Texas High Plains area which is presently based on irrigated agriculture is threatened by a rapidly declining ground-water supply. It is projected that, because of ground-water depletions, irrigation activity will begin to decline significantly by about 1980. Some of the fringe areas overlying shallow aquifers are already experiencing decline in irrigation activity. Augmentation of present supplies does not, at present, appear feasible. Long-range plans are needed to guide adjustments in agriculture to the declining ground-water situation.

Water and Related Land Use Problems – Rio Grande and Pecos Basins. – The problems of the Rio Grande and Pecos basins are as severe and complicated as any of the entire West. The two basins comprise, in all probability, the most water-short major region in the Nation. Their available surface water supplies are fully appropriated and used. There are serious shortages for irrigated agriculture. New water demands are generally being met by transfer of irrigation water to higher uses. Other problems include: serious overdrafts of ground water; excessive erosion and sedimentation; excessive salinity, especially in the Pecos basin; paradoxically, serious flood problems; dwindling wildlife habitat; inadequate provisions at existing lakes and reservoirs for flat-water recreation; water for Indians; and institutional problems involving State water rights and interstate compact commitments. Augmentation of water supplies by weather modification and by development and treatment of saline ground water appear to offer the only relief to this critical water shortage problem. Otherwise, a total water management plan is necessary to fit the existing supplies to the future of the region.

Water for Energy Resource Development. The great potential for energy resource development lies in the coal fields of northwest New Mexico in the Colorado River drainage. As New Mexico's assured share of Colorado River water is already fully commited, water for energy resource development will have to come from augmenting Colorado River supplies or from transfers in water uses.

Water for Indian Reservations. – New Mexico has 26 Indian reservations and pueblos located mainly along the Rio Grande and in the northwest portion of the State. They occupy a total of 10,200 square miles, or 9.4 percent of the total land area of New Mexico. In a state as water short as New Mexico, providing additional water for use on the reservations is a particularly difficult problem. The Navajo Indian project, now under construction, will provide significant new water, irrigation, and economic stimulus to the Navajo Tribe.

Oregon

Oregon has almost 2,100,000 people, the bulk of which resides in the western portion of the State, mainly in the Willamette Basin. Oregon is an area rich in the natural resources of land, water, timber, fish and wildlife, scenic beauty, and recreational wealth. It has little mineral reserves. Agriculture, including irrigated agriculture, timber processing, and recreation are leading industries. Diversified industrial plants are centered in the Portland area. The people of Oregon are dedicated to the maintenance of a desirable natural environment. The State is a leader in land use planning, pollution control, and preservation of scenic waterways. Fifty-two percent of Oregon is in Federal ownership. Oregon has abundant water supplies, although not evenly distributed, with almost 85 million acre-feet of runoff originating annually within its borders. Its more critical water and related resource problems, other than those discussed under Westwide and Regional Problems are as follows:

Figure 32. Elephant Butte Dam and Reservoir, New Mexico.

Municipal Water Supply. – Oregon has 183 small communities with a total population of 313,000 people that have inadequate municipal water supply facilities. The major problems concerning domestic water are generally inadequate storage and distribution systems and often insufficient water supply at the source. A large number of small coastal communities are in need of regional-type systems with upstream storage.

Instream Flow Values. – The high level of concern in Oregon for environmental values with respect to the State's rivers and streams has led to the creation of legal standing for flows in the streambed for such beneficial uses as recreation and fish and wildlife. The State, with technical assistance from Federal agencies, is actively engaged in establishing the level of desirable flows for these purposes in the major streams of the State. Before the desired flows can actually be provided and maintained in the streams with a guarantee that they will remain for their intended purposes, extensive water resource planning, development, and management will be necessary to overcome institutional, financial, and technological problems.

Management of Estuaries. – Oregon has a number of estuaries, all of which are facing increased pressure for use as recreational outlets, navigation and industrial developments, and from diversions of water upstream. Tillamook Bay and the Umpqua River estuary face the most critical problems. The Columbia River estuary, bordering the State on the northwest, is discussed under regional problems. There is a critical need for more environmental information on the estuaries, particularly as to necessary freshwater inflows, to better plan their future.

Total Water Management of Deschutes Basin. – The Deshutes basin has a number of interrelated water and land problems, many of which are caused by lack of adequate water supplies. The major components of the overall basin problem include: low flows in the river below the irrigation diversion structures at the city of Bend adversely affect the trout fishery and general scenic values; 117,000 acres of irrigated land need supplemental supplies; recreation and homesite developments are expanding with attendant pollution potentials; the cities of Prineville, Redmond, and Bend will need additional municipal and industrial supplies, and there are a number of rural domestic water supply problems; the Warm Springs Indian Reservation is concerned about available water supplies; there are problems related to maintenance of fish spawning grounds; there is infrequent flooding in the basin; there are wild and scenic river potentials; and Prineville Reservoir has 82,000 acre-feet of unassigned space for which the best use has not been determined. A total water management study is needed to provide an adequate plan to accommodate and resolve these various interrelated problems.

Total Water Management for the Malheur-Harney Lakes Drainage Basins. – The Malheur-Harney Lakes drainage, in the Oregon Closed Basin, is an interconnected hydraulic system receiving the flows from three major tributaries – the Silvies River, the Donner und Blitzen River, and Silver Creek. Major problems of the area are: high spring flows cause flooding, while low summer flows result in shortages of irrigation water; Malheur Lake lies within the Malheur National Wildlife Refuge and is the largest freshwater marsh in the Western

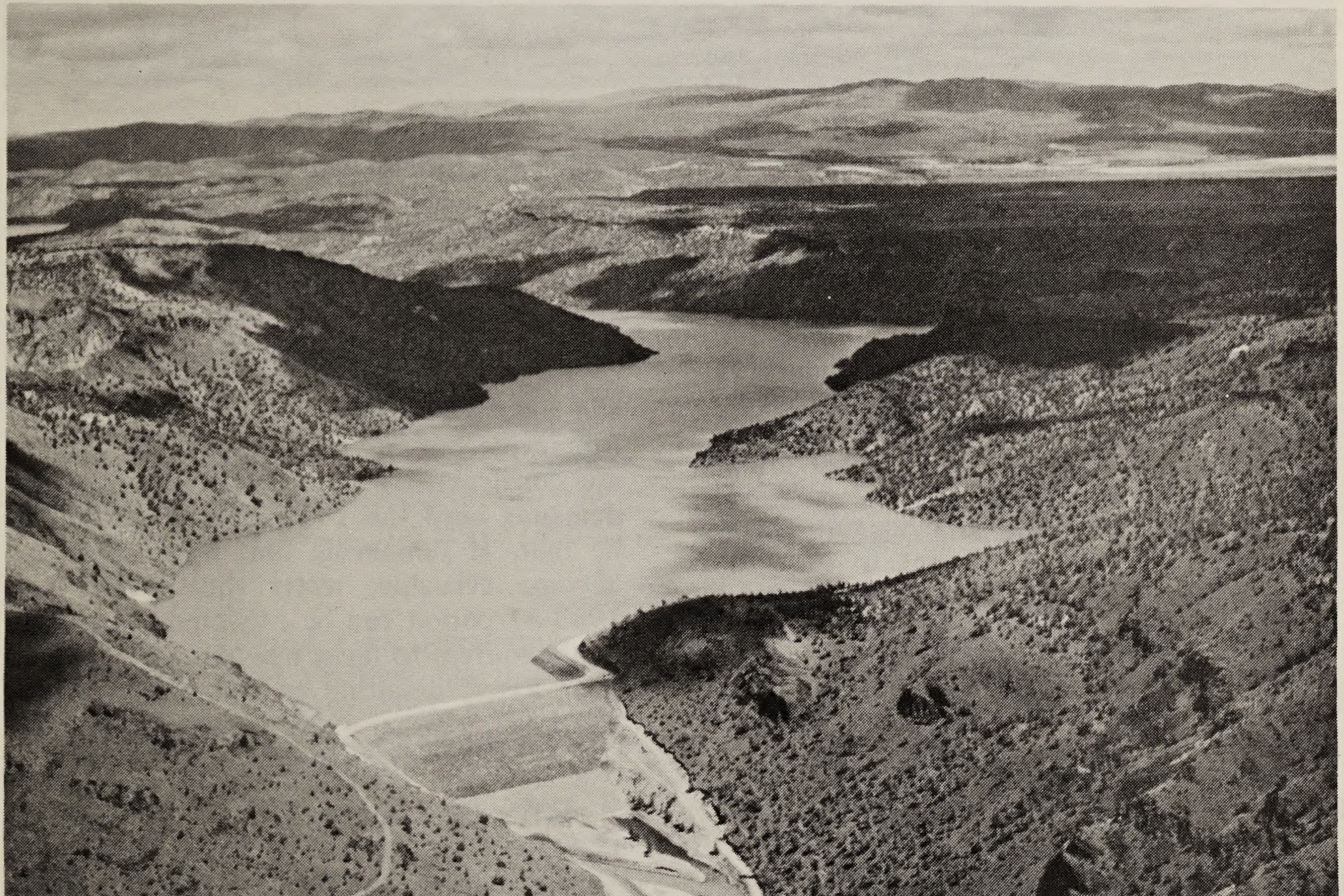


Figure 33. Prineville Reservoir, Oregon.

United States; any change in regimen of flow to Malheur Lake, which is at the lower end of the drainage, might adversely affect its important wildlife habitat values; Harney Lake, also within the Refuge, a natural swamp with no outlet, is normally too shallow, alkaline, and brackish for most uses, although it is heavily used by waterfowl and shore birds during high water years; and, there are problems relating to drainage, land erosion, municipal water supply, water-oriented recreation, and minimum flows for fish. A comprehensive, coordinated study of these interrelated problems is needed.

Flooding of Highly Developed Flood Plains and Urban Areas. – Although much progress has been made in the last 30 years in alleviating flood problems, flooding remains a major problem in Oregon. The areas of greatest concern occur where major population increases have been experienced and where developments have centered in flood plains. The areas of highest priority need for flood protection are along the main stem and tributaries of the Willamette River, the Umpqua River in the Roseburg area, and the Rogue River below Grants Pass. In the Grande Ronde River near the LaGrande area and the Silvies River basin flood damage potential is found in a more rural setting. The Corps of Engineers' flood protection program in Oregon, including flood plain management aspects, should continue.

Federal Assistance to Irrigation. – Oregon has millions of acres of land suitable for irrigation which lie adjacent to or within reach of available adequate water supplies. It is particularly important to Oregon that the proper future role of the Federal Government in assisting irrigation development be determined.

Utah

Utah has slightly more than 1 million people with almost 80 percent of its population concentrated in an 80-mile strip of communities centering in Salt Lake City and lying along the Wasatch Front. Utah's economy is diversified. Mineral resources, including copper, iron, coal, oil, gas, uranium, and precious metals, provide a significant part of the economic base. Irrigation, dryland farming, and rangeland suitable for grazing are important aspects of the agricultural economy. The State's scenic and wildlife attractions are contributing to an increasing tourist industry. Sixty-four percent of Utah is in Federal ownership. The Upper Colorado and Great Basins dominate Utah's water supply situation. Utah is presently using about 60 percent of its share of Colorado River water. Less than 10 percent of the Great Basin water supplies are unused and available to meet future demands. The more critical water and related land resource problems of Utah, other than those discussed under Westwide and Regional Problems, are as follows:

Municipal Water Supply. – There are about 100 domestic water systems in Utah which cannot meet health standards. Other communities are in short supply or have poor quality water.

Water Supply for the Wasatch Front. – Population and industrial growth along the Wasatch Front has been phenomenal in recent years and is expected to continue. Some local supplies, as well as a minor amount of ground water, are available to meet future demands but are not sufficient to meet long-term needs. If the municipal and industrial water supply features of the Bonneville unit of the Central Utah project are constructed as scheduled, future water demands until the 1990-95 time frame can be met. If Bonneville unit water does not become avialable, water shortages in the 1983-87 period can be expected to emerge. Other sources to meet new demands are the Bear River, desalting of water from Great Salt Lake, weather modification, and conversion of agricultural water to higher uses.

Salinity Problems. – Utah's salinity problems are in the lower reaches of the Sevier, Jordan, Bear, and Malad Rivers and in tributaries of the Colorado River. Salinity concentrations in the Lower Seiver River can limit the growing of truck crops and possibly

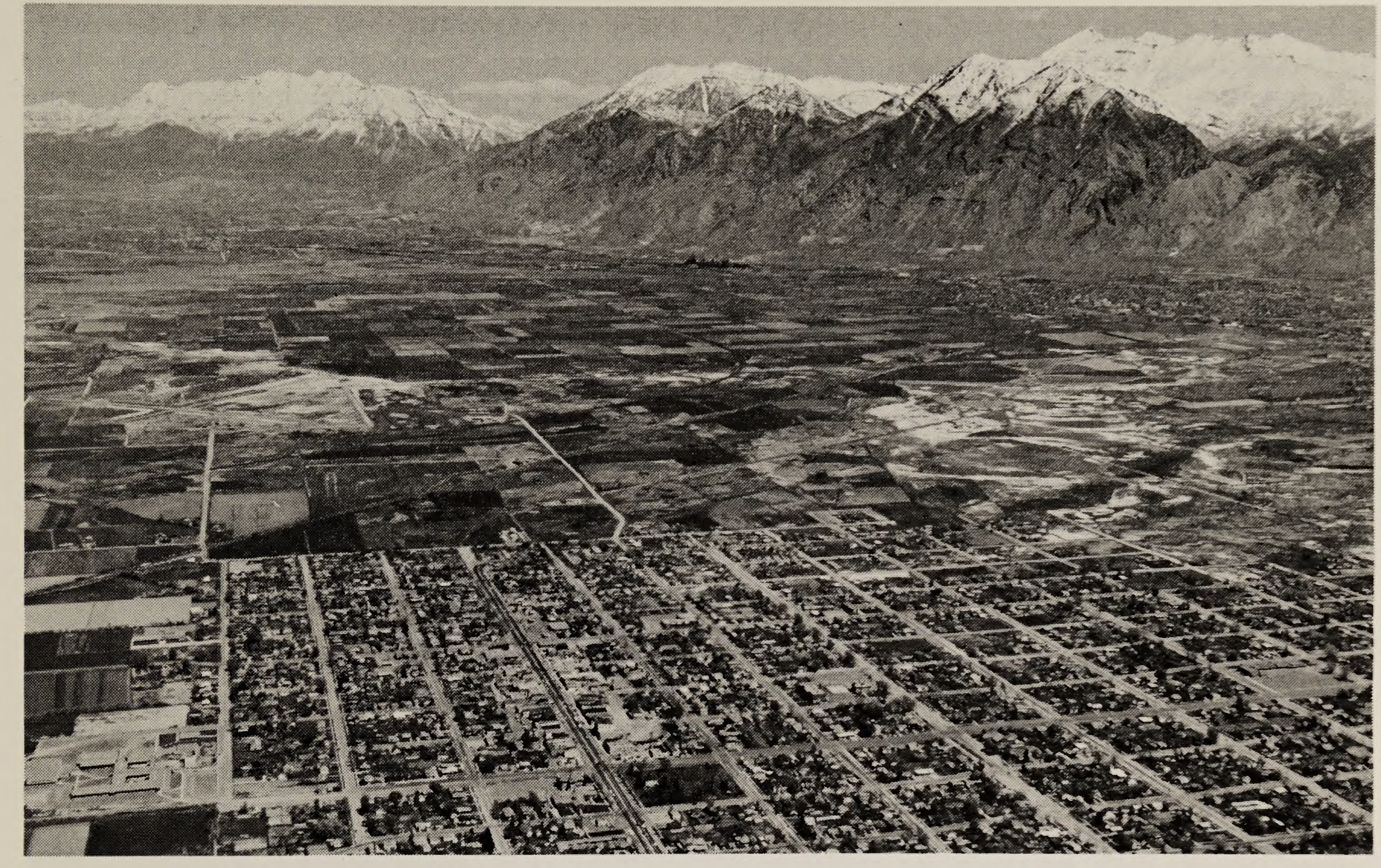


Figure 34. Wasatch front, north of Spanish Fork, Utah.

limit industrial use. On the Jordan, Bear, and Malad Rivers the lower river waters are used largely for wildlife refuges and high salinities are not particularly troublesome. As far as the Colorado River tributaries are concerned, salinity is not a significant problem within the State, but several Utah sources, mainly natural, do contribute measurably to the salinity problems of the lower Colorado River.

Jordan River Flood Plain Management. – The Jordan River problem has three basic components. The river poses a continuing threat of flooding in builtup metropolitan areas that have encroahced upon the flood plain. The river is polluted. The river has significant recreation potentials in an urban setting where development of recreation facilities has lagged behind public needs. A floodway-parkway concept has been endorsed by the State, and the Corps of Engineers with the cooperation of the Provo-Jordan River Parkway Authority is developing plans to resolve the problem. Recently the Department of the Interior approved a substantial water conservation fund grant request for the Lower Jordan River Parkway Project. Public acquisition of urban flood plain lands and development of recreation facilities suitable for flood-prone areas will begin in the near future.

Water for Energy Resource Development. – Utah has extensive coal deposits in the upper Colorado basin which can be developed to not only meet Utah's energy needs but a substantial block of the Nation's needs as well. To develop these reserves would require dedicating a good portion, if not all, of Utah's remaining uncommitted share of Colorado River water to this purpose. Insofar as water is concerned, it is the competition of other potential uses for this water, combined with environmental considerations, that raises the problem.

Water for Indian Reservations. – In 1965, the Ute Indian Tribe of the Uinta and Ouray Reservations agreed to defer development of some of its lands in order that the Bonneville unit of the Central Utah project could be constructed. It was anticipated at the time that adequate compensation for their deferral would be forthcoming in the later development of the Uinta and Ute Indian units. Progress toward development of the units has not met expectations, giving rise to the current problem.

Commitment of Remaining Colorado River Water. – Final decision on the use to be made of Utah's remaining uncommitted share of Colorado River water pervades almost all aspects of future water resources planning for Utah. It will determine how much water will be made available for energy resource development. It will affect the manner in which the Wasatch Front urban area meets its future water demands. It will affect the development of Indian resources. It will affect recreation, fish and wildlife, and other environmental considerations. There is urgent need for the State to reach an early decision.

Washington

Washington has about 3,500,000 people with the greatest concentration of population in the western part of the State, particularly in the Puget Sound area. Washington, like Oregon, is rich in land, water, forests, fish and wildlife, scenic beauty, and recreational values. It has little mineral reserves. Agriculture, especially irrigated agriculture, forest products, and recreation, are leading industries. Major diversified industrial plants are centered in the Seattle-Tacoma-Everett complex. Thirty-five percent of the State is in Federal ownership. Washington contains a total of 22 Indian reservations, 2 groups of Indian trust public domain allotments, and a group of Indian fishing sites on the Columbia River. Surface water supplies originating in Washington average about 95 million acre-feet per year, more than any other State in the coterminous United States, although they are unevenly distributed. The more critical water and related land-resource problems of Washington, other than those discussed under Westwide and Regional Problems, are as follows:

Municipal Water Supply. – There are 85 cities and communities listed in Washington with water quantity, water quality, or distribution system problems. Pacific beach areas have limited local water supplies and wells are subject to saltwater intrusion. Supplies are short for many Puget Sound islands. Communities in east-central Washington are experiencing domestic water supply problems because of declining ground-water aquifers. Importation of additional supplies for groups of communities appears feasible in some instances.

Competing Uses in the Okanogan River Basin. – A variety of competing uses exist for the land and water of the international Okanogan River basin. Among the critical problems in need of solution are: water quality and instream needs, especially for temperature control; flood damage at major communities in the basin, amounting to an average of $824,000 annually; recreation use on the river limited by poor quality water; municipal water needed at Okanogan, Omak, and Oroville; anadromous fish and other fish and wildlife threatened by poor water quality and inadequate river flows; supplemental water for irrigation and rehabilitation of inefficient systems; and water requirements on Colville Indian Reservation. The present level B study of the Okanogan River basin will provide direction to resolving the major resource development and management needs of the basin and should be followed with specific studies for programs to assure the best long-range use of the basin's resources.

Competing Uses in the Yakima River Basin. – The Yakima River basin has severe problems relating to poor water quality caused by agricultural return flows, septic tanks, municipal and industrial waste effluents, farm animal wastes, and diversions for consumptive uses; average annual flood damages of $1,800,000; damage to anadromous fishery caused by poor water quality, low riverflows, poor fish passage facilities, and overfishing; need for supplemental irrigation water for at least 100,000 acres; lack of recreational opportunities; Yakima Indian Tribe developmental potentials; and inadequate municipal water supplies. The present level B study of the Yakima River basin will provide direction to resolving major resource development and management needs of the basin and should be followed with specific studies for programs to assure the best long-range use of the basin's resources.

Management of Estuaries. – The estuaries of Washington, outside Puget Sound, are relatively undeveloped. However, as population, commerce, and industrial activities increase, pressures for competing uses arise. Unplanned and uncontrolled uses of the estuaries can result in damage to them. Now is the time for study and for development of management criteria to avoid such damage. The estuaries considered most critical are the Puget Sound, Willapa Bay, and Grays Harbor. The Columbia River estuary is discussed as a separate regional issue.

Resource Development and Management Needs in the Big Bend Area. – The Big Bend area embraces a vast area in central Washington and is bounded on the north, west, and south by the Columbia River. Within this area, there are a number of interrelated water and land resource developmental and preservation problems involving new irrigation potential of over 2 million acres; public land management for over 3 million acres; including grazing management, streambank stabilization, burn rehabilitation and dust control; flood control; declining ground

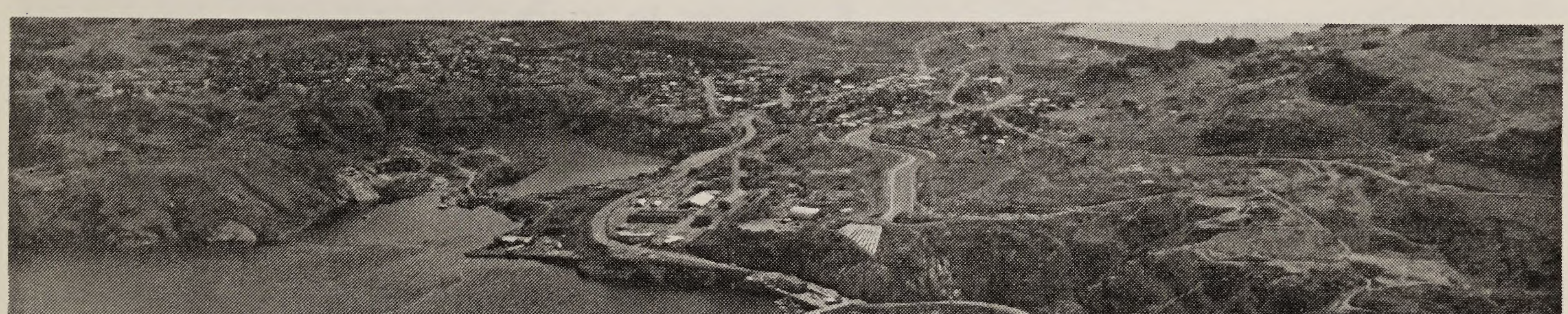


Figure 35. Grand Coulee Dam, Washington, with Third Powerplant nearing completion.

water; poor water quality; recreation; fish and wildlife enhancement; power potential; environmental quality; and municipal and industrial water supply. The present level B study of the Big Bend area will provide direction to resolving the major resource development and management needs of the area and should be followed with specific studies for programs to assure the best long-range use of the area's resources.

Flooding of Highly Developed Flood Plains and Urban Areas. – Although much progress has been made in alleviating flood damages, there remain several serious problem areas in the State. These are along the Nooksack, Skagit, Stillaguamish, Snohomish, Cedar, and Nisqually Rivers in the Puget Sound regions and along the Yakima and Okanogan Rivers in central Washington. The Corps of Engineers' flood damage reduction programs which address these problem areas should continue.

Hydroelectric Power. – The potential for new hydroplants and additions to existing plants approaches 15,000 megawatts in Washington. In addition, pumped-storage potential in western Washington is enormous, having been estimated at 46,000 megawatts in the Puget Sound area alone. The eastern part of the State also has several attractive pumped-storage potentials. Many of the pumped storage and new hydrosites could involve conflicts with environmental values. At existing plants, especially along the main stem of the Columbia River, additional capacity could be installed with a minimum of environmental impact, and could assist in solving the problem of nitrogen supersaturation which is damaging to anadromous fish. The remaining new hydropower potential in Washington and additions to existing powerplants should be reevaluated in light of the energy crisis and new values for energy.

Federal Assistance to Irrigation. – Washington has millions of potentially irrigable acres located adjacent to or within easy reach of adequate available water supplies. It is of especial importance to the State that the proper future role of the Federal Government in assisting irrigation development be defined.

Wyoming

Wyoming has a population of 332,000, which amounts to about three people per square mile. It has abundant natural resources, including vast mineral reserves, timber, grazing lands, and some of the finest scenic and outdoor recreation areas in the Nation. The oil and gas industry is presently the largest mineral industry with coal and uranium on the increase. The expanding trona industry is also important. Agricultural activities, covering about 84 percent of Wyoming's land area, center in livestock and livestock products. Tourism is Wyoming's third largest industry. Forty-seven percent of Wyoming is in Federal ownership. Wyoming watersheds contribute water to rivers of four major water resource regions – Columbia-North Pacific, Missouri, Colorado, and Great Basin. Except for the North Platte River area, the water supplies of Wyoming appear ample to meet needs for many years to come.

The more critical water and related land resource problems of Wyoming, other than those discussed under Westwide and Regional Problems, are as follows:

Municipal Water Supplies. – Wyoming has 25 communities with a total population of 26,000 people with critical water supply problems. Nearly 28 percent of the people in Wyoming are now facing or will face some type of domestic water quality or quantity problem. Most of the towns facing these problems depend upon ground water for their sources. Some of the ground-water supplies are of poor quality and many are of limited quantity. Other areas that are facing immediate problems are those near the developing coal resource areas.

Water for Energy Development. – The major problem involving Wyoming's available water

Figure 36. Jackson Lake and Grand Tetons, Wyoming.

resources is in relation to development of its extensive energy resources. Wyoming's coal resources consist of about 121 billion tons, of which 70 billion tons are recoverable. The State produces 28 percent of the Nation's uranium. It has extensive oil shale deposits. Development of these resources, which is now under way for coal and uranium and which is expected to start shortly for oil shale, can play a major role in meeting national energy needs. Their development, however, will have an impact on the present environment, communities, Indian Tribes, and irrigation development. Present development is now proceeding piece-meal. Industry is purchasing irrigation water for mineral production and processing and for coal-fired thermal electric plants, thus taking presently irrigated land out of production and causing economic displacement. Additional water-storage facilities that would regulate the available unused surface flows to make these supplies available for industrial and other uses are needed. Comprehensive studies are needed to relate long-term energy demands for water to available supplies.

Salinity Control. – Wyoming has no serious salinity situations that affect activities within the State. However, the Big Sandy River in the Green River basin contributes substantial amounts of dissolved solids annually, the major portion of which comes from natural sources. A control program to remove almost one-half of the salt annually would significantly reduce salinity concentrations on the Colorado River at Imperial Dam by an estimated seven parts per million.

POTENTIAL INVESTIGATIONS

Having identified and described the major critical water and related resource problems of the 11 Western States, the Westwide Management Group recommended 72 specific Federal investigations for the 1976-1985 period to find solutions to those problems. These investigations, if carried out, will involve 18 different Federal agencies and cost a total of $167 million for the 10-year period. Details on these investigations including nature, location, individual cost, timing, and Federal agency participation are contained in the main report at the end of chapter VI.

An insight to the overall character of the investigations recommended by this group is revealed in the breakdown of the $167 million total for the 1976-1985 period by primary purpose of the investigation shown in the table below.

Estimated Costs of Recommended Investigations

Purpose	Total (thousands)	Time Period	
		1976-1980	1981-1985
Water for Indian Reservations	$ 35,000	$ 9,944	$ 25,056
Environmental planning	41,850	32,800	9,050
Energy-related resource planning	10,100	9,680	420
Augmentation of water supply (weather modification)	37,650	13,400	24,250
Water quality	13,300	8,000	5,300
Basin studies (Level B)	9,550	9,050	500
Estuaries	2,500	2,500	0
Total water management	7,900	6,100	1,800
Flood control	5,300	4,700	600
Municipal and industrial (other than energy)	1,500	900	600
Miscellaneous	1,900	1,650	250
Total	$ 166,550	$ 98,724	$ 67,826

Practically all of the above investigations are of the broad program type rather than project oriented. They are aimed at accommodating such objectives as meeting Indian requirements, providing environmental information to facilitate future resource conservations and development decisions, augmenting water supplies, improving water quality and total water management of major river systems.

These investigations are intended to supplement not replace ongoing investigation programs which are required to meet water and water-related needs throughout the West. To put into perspective the annual study costs of about $20 million for the 1976-1980 period, they compare to the average annual Federal agency expenditure on water resource investigations in the 11 Western States of $88 million.

GENERAL OBSERVATIONS

In the process of identifying and describing water and related resource problems deserving priority attention, a number of observations surfaced concerning the problems identified and also concerning future water and related resources planning and management activities. The resulting observations, which reflect general consensus of those intimately involved in the Westwide Study, are summarized for consideration to guide future studies and provide input into continually evolving National water policy.

Major Problem Areas

Almost 100 specific problems of water and related resource conservation and development in the 11 Western States have been identified by the Westwide Study as being of sufficient magnitude and importance to deserve attention not now being given to them.

In the closing months of the Westwide Study considerable thought and attention were devoted to establishing a priority rating for these problems reflecting the seriousness or importance of each individual problem. Considering the wide range and diversity of the problems; the extensive geographical coverage of the study; and the many disciplines, agencies, States, and other interests involved, a Federal priority list was not developed. Nevertheless, the Westwide Management Group did come to essential agreement that the specifically identified problems for the most part fall into a number of major problem areas, the resolution of which will have widespread impact and importance throughout the 11 Western States. The following listed problem areas which are discussed either specifically or by inference in some detail under the headings of *Westwide Problems* or *Regional Problems* are considered, in effect, the highest priority problem areas in the West. The order of their listing carries no priority significance.

Water for Energy Resource Development
Water for Small Communities
Water for Indians
The Environmental Data Gap
Colorado River Water Supply and Salinity
Augmentation of Natural Supplies
Water Conservation and Reuse
Coordinated Land and Water Use Planning Including Flood Plain Management
Federal Assistance to Irrigation Development
Protection of Estuaries
Increasing Salinity in Major River Systems
Erosion and Sedimentation
Water for Public Lands
Preservation vs. Development

Improving Water Planning Organizational Arrangements

From the experience gained in the Westwide Study effort, a number of organizational arrangements are indicated as needed to improve coordinated water resources planning in the future. River basin commissions appear to provide the best organizational structure now available under present laws and policies for broad-scale regional water and related land planning. Interagency and ad hoc groups provide a useful coordination service but are unwieldy and lack authority to establish overall study priorities and the formulation of alternative plans. Deficiencies that hamper river basin commission operations include lack of centralized funding authority, uneven and inadequate funding levels, dependence upon participating agencies, and lack of authority over mission-oriented and separately funded agencies.

Natural hydrologic boundaries may be suited to the solution of certain water problems but may not be the best approach to resolve more complex natural resource problems where water is only one input in the matrix of decisionmaking. Regionalization along State boundaries should enhance the effectiveness in planning for water and related land resources.

Increased State participation is vital to the planning process but in most States in the West is hampered by lack of funds and staff. The use of State Study teams with multiagency, multidisciplinary, State, and Federal representation proved to be a successful procedure in the conduct of the Westwide Study. Many of the teams included representation from Indian, private, and public groups and local participation was encouraged.

Even though there was an extremely close working relationship among Federal agencies in the Westwide endeavor, it was evident on many occasions that differing interpretations of National and State policies and differing agency missions and objectives hampered and inhibited the process of obtaining consensus on what problems were critical, what steps should be taken to resolve problems, and which agencies should lead studies. This has been a problem common to all Federal interagency study groups. It indicates the need for action at the National level to strengthen organizational arrangements for water and related land resources planning such as the establishment and maintenance of a national entity empowered to interpret National policies and to achieve their uniform application among agencies. Provisions should be made for the necessary modification and establishment of regional planning entities along State boundaries as necessary. The organization of multidisciplinary-multiagency, State-Federal Study Teams to provide leadership and guidance to both ongoing and future water and related land resource investigations is recommended as an immediate step toward more effective planning.

Total Water Management for Highly Developed River Basins

Most of the highly developed river basins in the Westwide area now are experiencing competing demands which are arising from changing public values. In some basins, the available water supply is completely regulated and used. In others, the remaining supply is under major controversy between diversion for consumptive use and instream uses. New public voices are demanding increased recreational opportunities, enhancement of the environment, protection of fish and wildlife, and improvement in the quality of water flowing in the rivers and streams. On the other hand, increasing population, new industrial growth, energy development, and continuing increases in irrigated agriculture are competing strongly in the economic area for additional water.

There is a great potential within these basins to achieve a better balance among various demands for use of the water and to do a better job of satisfying each through better management of existing facilities and control structures or with a few key additions to the system. Deriving the greatest overall benefits from a river system through river operation requires careful weighing of the management alternatives.

Total water management should emphasize flexibility of system operations, including modification of existing projects, to respond to changes in public needs and desires. The overall objective must be to operate the river system insofar as practicable so that each use or need will be met proportionate to its public values.

Ground Water Development and Management

As surface water supplies have become depleted, particularly in the southwest, more and more reliance has been placed on ground water. In many areas, conjunctive use of surface and ground water has greatly extended the water supply available for use and has proven to be an effective way of maintaining water service during drought periods. In still other areas, the extent of the ground-water supply is relatively unknown. Local, State, and Federal interests have made significant expenditures in ground-water investigations for many years, yet there are major gaps in information. Ground-water studies should be undertaken before water supplies become critical.

Both Federal and State efforts should be intensified in developing ground water information. A greater degree of ground water monitoring should be established for early detection of pollution. Selective ground-water investigations should be increased in those areas where potential water supplies may be available to meet critical water needs.

Flood Damage Control

Specific flood damage reduction programs were considered in the preparation of this report only where they directly related to the primary area of interest of future water supply. On this basis, nearly all ongoing flood damage reduction programs were intentionally excluded. Only those flood control studies which had potential impacts upon water quality or water quantities, such as projects with storage potentials, were reviewed and then only those with major impacts were included. This treatment of flood damage reduction programs should not be considered as detracting from their importance but as an affirmation of the desire to keep the focus of the study consistent with the enabling legislation. Ongoing flood damage reduction studies and programs of the involved Federal agencies are intended to result in the reduction of flood hazards and risks to property and persons. Today more emphasis is being placed on zoning, flood proofing, and land uses such as greenways, parks, and open spaces as alternatives and complementary features to purely structural measures in well-conceived comprehensive flood damage reduction plans.

Legal and Institutional Improvements

As new emphasis for uses of water has emerged over time, legal and institutional arrangements have not kept pace. Better response to public demands and increased efficiencies in water use could be improved by changes in water law and administration.

The basic water rights laws (first in time, first in right) served the people well in the development of the West. As competition for water has increased, these laws have been modified to better define "beneficial use" to clarify what part of a diversion right can be transferred to other owners and uses and to better manage surface and ground water withdrawals for protection of all users. Much remains to be done, however, to improve the present body of water law. Water rights although designed protect and treat fairly all rights holders, hav complicated the allocation of scarce supplies of water to those uses most important to the rapidly changing cultural and economic conditions. The enhancement of Federal and State water pollution control laws has added a new dimension to the legal setting.

The matter of State water law is the responsibility of individual States. They, therefore, should take the lead to update all aspects of water law to facilitate the allocation of water to meet changing social demands and to require a high level of efficiency in all uses. Such changes in water law should be commensurate with the proper utilization and conservation of natural resources over time.

Trends in Future Water Planning

An inescapable conclusion of the Westwide Study is that the objectives and character of Federal Agency water and related resource planning programs are undergoing significant change. Historically, Federal agency planning programs were project oriented with the authorization and construction of new projects in most cases the ultimate result. Testimony to this is the huge and growing backlog of authorized but unconstructed Federal projects and also of planned but unauthorized projects.

While projects are and will remain important to water resources conservation and development, current trends in planning are placing greater emphasis on much broader objectives attuned to meeting a wide variety of human needs. Under the new Principles and Standards, environmental considerations as well as those of economic efficiency are valid objectives of water resources planning, and alternative plans to stress these differing values are required. Many existing authorized but unconstructed projects are being, or will have to be, reevaluated with these new objectives in mind. The new thrust in planning also centers around major areas involving such matters as total water management, augmentation of water supplies, energy resource development, conservation and reuse of water, environmental quality improvement, water quality improvement, and development of Indian resources.

Water and related planning must be a continuing activity in the West, even after the bulk of the desirable water supply and regulation features has been constructed. With water so critical to the economy and the well-being of the Western population, there will be a continuing demand for changes in use, technological advancements permitting more efficient water use, and need for information to guide desirable institutional changes. Total water management planning, participated in by both State and Federal water agencies, will become more and more the norm as the remaining water supplies of the West are dedicated to use.

THE STUDY YEARS AHEAD

The manner in which the water and related land resource problems of the West are resolved; the time limit within which they are resolved; and the substance of their resolution can have enormous influence on the economic, social, and environmental future of the West and of the Nation. Involved are issues and resources that can affect deeply the capabilities of this Nation to meet its energy needs which, in turn, affect the very lifestyle of its people. Involved is the future character of one of the great heritages of the West – its wide open spaces, its wild and scenic rivers, its unspoiled wilderness areas. Involved are resources and considerations affecting critically the future of the American Indian. Involved are the future of several of America's largest and most important river system – the Columbia, Colorado, Sacramento, San Joaquin, Rio Grande, and the headwaters of the Missouri.

In reporting out the Colorado River Basin project legislation, which authorized the Westwide Study, the Committee of Conference indicated that the investigations and studies to be undertaken thereto were to reflect only the first phase of study. The committee stated the intent that the Secretary of the Interior thereafter should continue, pursuant to existing authority to pursue vigorously the development of a general plan to meet the future water needs of the entire Western United States and that he should make recommendations to this end for further studies as are justified and appropriate.

The investigations recommended herein for the 1976-1985 period are considered essential to the objective of developing a general plan to meet the future water needs of the Western States. The program of studies was structured to reflect present and foreseeable trends in water planning and to accommodate the priorities of the next quarter century. For the program to accomplish its purpose, the 18 involved Federal agencies must support it and include appropriate parts of it in their forthcoming annual budget proposals, which many are now doing for fiscal year 1976. The Administration and the Congress must give followup support. The states and other interests must also demonstrate support and, where called for, take appropriate associated actions. Only through such united support and action will the pressing water and related land resources problems of the West, highlighted in this report, receive timely study and resolution and a responsive plan to meet future water needs evolve.

☆ U. S. GOVERNMENT PRINTING OFFICE 1975 - 680-527/208 Reg. 8

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

RECEIVED
Bureau of Land Management
State Director
OCT 23 1975
Cheyenne, Wyoming